THE TRACKMAN'S HELPER

A HAND BOOK FOR TRACK FOREMEN, SUPERVISORS AND ENGINEERS

1917 EDITION

REVISED AND ENLARGED
BY

RICHARD T. DANA and A. F. TRIMBLE

Mem. Am. Soc. C. E.
Mem. Am. Soc. E. C.
Mem. A. I. M. E.

Mem. Am. Ry. Eng. Assn.
Mem. Eng. Soc. N. E. Penna.

AFTER THE ORIGINAL
BY

J. KINDELAN
of the C. M. & St. P. Ry.

AS REVISED BY

F. A. SMITH
F. R. COATES
and
JERRY SULLIVAN

ILLUSTRATED

1915 Clark Book Co. Inc.

NEW YORK
1917

PREFACE

The object of this book is to help the MAN ON THE TRACK by giving him in the most convenient form the practical results of observation and study of track work on the railroads of the United States for the last twenty years, in addition to the notes that were published in 1894 by the late J. Kindelan.

The original book has been entirely rewritten and brought up to date, the illustrations redrawn and a great many new ones made. A very large quantity of brand new material has been added from the experience of the authors and from the files of the technical journals, which have been carefully searched for the purpose.

We have kept constantly in mind the following points that are necessary in a practical book of this kind, namely:—

(1) It must cover the principal field of a trackman's work.

(2) It must not waste space by going outside of that field.

(3) It must avoid elaborate theories, which he has not the time to investigate.

(4) Its language must be plain enough to be readily understood.

(5) It must be small enough to be carried in his pocket.

(6) Its price must be within his means.

In writing this volume our final aim has been to enable each man who uses it to become of the greatest possible value to the company that employs him.

RICHARD T. DANA and A. F. TRIMBLE.

New York, November, 1916.

TABLE OF CONTENTS

TABLE OF CONTENTS

THE TRACKMAN'S HELPER

I

CONSTRUCTION

Requirements of new track. A good railroad should be complete in all respects. In its construction nothing should be omitted that may contribute towards making it safe and economical for operation. It should be full-bolted, spiked, well ballasted, surfaced, lined, and gaged. A poor track bears about the same relation to a railroad that a shanty does to a house, and trackmen who are in the habit of doing poor work, with means at hand to do better work, never learn how to do good work.

Track laying. The best dirt ballasted track can be made by bedding the ties to a level surface across their tops before putting on the rails. To do this engineers must first set grade stakes, which are usually placed 100 ft. apart. For very accurate work they may be set every 25 ft. if the engineers have time, which seldom happens. The ties can then be set between the 25 ft. stakes with strings.

Track laying machines. These have been used to a considerable extent in building new roads and are elsewhere quite fully described in this volume with cost data of their operation. The amount of track laid each day must always be limited to what can be bolted and spiked safe for trains between the forward moves of the machine. The secret of success in laying track in this manner, just as in all cases involving large operations, lies in the proper preparation and

the accurate organization of the entire work. In the United States to-day, the vast bulk of track work consists of re-laying under conditions that are not suitable for track machine work.

Tools and material for track laying. The following is a list of tools ordinarily required on construction work for track laying and ballasting where 100 men are employed:

Hand Cars	2
Push Cars	2
Track Shovels (#1 Flat)	100
Shovels, Round Pointed	24
" Long Handled	6
Picks	50
Lining Bars	12
Claw Bars	12
Tamping Bars	12
Nipping Bars	12
Cold Chisels	24
Rail Punches	6
Chopping Axes	6
Hand Axes	6
Adze Handles	24
Axe "	6
Spike Maul Handles	36
Red Flags	12
Sledges, 16 pound each	2
" 12 " "	2
Grind Stone	1
Track Wrenches	24
Rail Tongs	12
Rail Forks	6
Expansion Shims	200
Switch Locks	6
Rail Drills	2
Torpedoes, dozens	4
Spike Mauls	36
Bush Scythes and Snaths, each	6
Hand Saws	6
Adzes	12
Track Gages	12
Spirit Levels	4
Tape Lines	4
Claw Hammers	2
Monkey Wrenches 18″	2
" " 12″	2
Lanterns, Red	6
" White	6
Water Pails	6
Tin Dippers	12
Oil Cans	2
Oilers	2
Gallons of Oil	2
Nails, each of 10d, 20d, 40d, 60d	Keg
Pick Handles	24
Track Jacks #1	4
" " #6	2
Rail Benders	2
Covered Water Barrels	2
Chalk Lines	2
Files	6
Crosscut Saws	2
Post-hole Diggers	2
1¼-inch rope	300 feet
Tie Poles, 30 feet long	2
Tie Gages	4
Set Double Harness	1
Set Single Harness	1
Set of Double and Single Trees, each	1
Wagon	1
Scrapers	2
Horses or Mules	2
Tool Boxes	2
Wheelbarrows	12
Trackbarrows	6

The above list of tools will do to supply an average gang of 100 men employed on tracklaying and ballasting with a surplus to equip extra men if required, or replace tools out of repair or broken, until supplies ordered can be secured.

The accommodations for tracklaying should be about as follows:

One supply and office car.
One kitchen car.
Two dining cars.
Ten sleeping cars.

Where tracklaying is done at a long distance from the base of supplies a blacksmith with forge and tools should accompany the outfit.

Blacksmith shop outfit. Tools necessary for a blacksmith shop suitable for drill and general repair work are given in Dana's "Handbook of Construction Plant," as follows:

1 anvil, 130 lbs.	$13.00
2 augers, ship, 1⅞, $1, 1-1″, $1.20	2.20
2 bevels, universal	2.50
1 brace and 13 auger bits, ¼ to 1″, in roll	5.50
1 caliper, micrometer	6.00
4 calipers, spring, at $1	4.00
6 chisels cold, 12 lbs. at 50¢	6.00
4 chisels, hot, 8 lbs. at 50¢	4.00
1 cutter for pipe up to 3″	4.80
1 drill, stationary, hand power, ¼ to 1¼ hole, weighs 170 lbs.	22.00
1 drill, breast	3.00
6 drill dollies	10.00
24 files, assorted, at $8 per doz.	16.00
24 files, flat, at $8 per dozen	16.00
12 files, small taper	.60
24 files, triangular, at $7 per dozen	14.00
1 grindstone, foot power, 3″ x 12″ wheel	4.00
1 gauge, marking	2.00
4 heading tools, 1½ lbs. each	3.00
3 hammers, blacksmith	2.70
3 hammers, set	1.50
4 hardies at 50¢ lb.	2.00

2 pails at 70¢	$ 1.40
6 rasps, at $12 per doz.	6.00
1 rule, 6 ft. folding	.40
1 saw, crosscut, hand, 26″	1.35
1 saw set	.70
2 saws, hack, at $1	2.00
4 shanks	2.00
1 sledge, double face, 5 lbs.	1.50
2 sledges, double face, 7 lbs. each	4.20
1 sledge, cross pein, 5 lbs.	1.50
2 sledges, cross pein, 4 lbs. each	2.80
2 squares at $9	18.00
1 stock and 8 dies for ½″ to 2″ pipe	17.50
8 swedges, bottom, 1 lb. each	2.00
8 swedges, top, 1 lb. each	2.00
9 tongs, assorted	12.00
1 vise, blacksmith's leg, 6¼″	20.00
1 vise, hinged, for pipe, ⅛″ to 3″	3.15
	$243.30

Tie bedding. This work consists in placing a straight edge in a level position over the tops of loose ties lying on the sub-grade, and bringing up each tie to a uniform surface under the straight edge, just as it should be in track under rails. Thin ties should have ballast thrown under them and be settled to the correct level. The bed under thick ties should be dug out and the dirt removed sufficiently to bring the tie down to the level of the other ties. One straight edge should be provided for every two men of the tie bedding gang. With dirt from the embankment, the thick ties should always be bedded before laying the rails, because the grade is seldom a smooth surface to receive the ties; the ties, no matter how well selected, vary in thickness, and it is well known that the rails laid on loose ties and uneven grade will be kinked and surface bent by trains running over the track before it is surfaced up smooth and level. Another good point in favor of tie bedding is that the rails can be laid faster than over

loose ties, and the spiking can be better done with less labor.

Engineers should call the attention of the contractor to inequalities or poor surface of grade. It is much easier and cheaper to make a good grade with teams and scrapers than with shovels.

The general practice now is to follow up with ballasting practically as fast as the rails are laid and with hopper and ballast cars that enable the distribution of the material used in ballasting just as it is needed. Tie bedding is done sparingly and only to the extent of getting the track laid so that it will carry a work train for a trip or two, "to drag the track" full of ballast or perhaps get a few cars of steel ahead for the rail laying gang.

Track laying. There should be a good foreman in charge of the track laying gang and he should keep general oversight of the work and keep the men properly proportioned to the work of distributing ties, laying rail, and spiking and gaging. For each of these three classes of work an assistant foreman should be employed who will be in direct charge and hurry the work along. The general foreman should see that the work is properly done, and help out the sub gang that he sees is getting behind, making such change in the proportion of men alloted to each as he sees is for the best to keep the work in the different lines advancing continuously and at the same rate of speed. If the laborers employed are foreigners it is well to have assistant foremen who can speak their language. The general foreman, while he may be competent, cannot look after all the details and keep a large gang of men working to advantage. It is money well spent to have sufficient assistant foremen, who should be held responsible for having all necessary tools at hand when wanted and for carrying on the work assigned.

Locating joint ties. Two men should be delegated to carry a measuring pole of the correct length of a rail for locating the joint ties ahead of the rails. These men should space the ties on each side of the joint wherever necessary; they should also adze twisted ties and bed down those that are too high. The joint ties should not be located very far ahead of the rail, because there is likely to be variation in the distances, and the measurements taken with the pole should occasionally be corrected from the ends of the rails. The track laying is delayed and the ties are seldom so well spaced when the work is left to the spikers.

Tie gage. The two men who look after the location of the joint ties can also mark the location of the base of the rail on each tie by means of the tie gage, which is a template or stick that should always be on hand for this purpose. Its use is explained more fully and an illustration of it given in Chapter V under "Renewal of Ties." This marking of the position of the rails requires only very little time and should always be done, as it saves much valuable time for the spikers in getting the tie quickly adjusted to its proper position.

Laying the rails. A construction foreman should see that no new rails are laid in track before all kinked and crooked places in the rails are straightened. It has been a common fault when in a hurry to spike down all rails just as they come, regardless of any kinks that may have been put in them while in transit or in unloading them from cars. Many lightweight rails are irreparably damaged in this way, and after such rails are put in a track they are seldom, if ever, made perfect again, as very few section foremen have the necessary amount of help or spare time to do what can be done in the very short time before the rails are laid. The foreman should

see that the rails are so laid that no joint will come within ten feet of the end of any bridge or road crossing where this can be avoided. For this purpose it is the practice of some roads now to furnish double length rails, i.e., 60 ft. or 66 ft. long, which are in most cases sufficient to clear the travelled road with a single length and thus eliminate an endless amount of trouble on maintenance. It is also a good plan to lay long rails at station platforms where it is difficult to resurface joints on account of the track being filled in to the top of the rails or planked over as at road crossings; and on bridges, in addition to getting easier riding qualities, there is a great amount of shock saved to the bridge structure by the elimination of half of the joints. When placing the order for new rails there is no particular difficulty in figuring out how many long rails are necessary to meet these conditions.

Expansion and contraction. When laying rails care should be taken to provide the proper spaces at the joints for expansion. If they are laid with too close joints in cold weather they expand and close up all the openings as the weather becomes warmer until finally, when there is no further room for expansion as the heat increases, the track becomes kinked out of line or "buckled." This is an extreme condition and is disastrous when it occurs ahead of a train, as sometimes happens, causing a derailment.

The effect of expansion of the rails is most noticeable on a line of track that is only partially ballasted and filled between the ties, or where track has been laid down without any particular ballast. This effect may exist only to the extent of making each individual rail-length of track "wavy," and slight kinks can be noticed at the joints, but it is something to be guarded against. When the rails are crowded together tightly so that there is no room for ex-

pansion in forty or fifty rail lengths, it is time for the section foreman to take it in hand. He should either bump the rails back if there is opening to do so, or cut a few inches from a rail in the center of the tight track and bump the adjoining rails to divide up the opening so obtained throughout a number of rail lengths either way. In cutting a rail for this purpose it is best to cut from the end an amount equal to the distance between the first and second bolt holes, or, in other words, have it so that the second bolt hole will move up to take the place of the one cut off.

"Contraction" is a shrinking or shortening of the rails, and is caused by cold weather. The contraction of the rails increases with the severity of the cold, and by this process the openings in the joints between the rails are enlarged.

Sometimes in the winter the contraction is so great that where the rails were not properly laid the track is torn apart, joint splices are broken, and openings between the rails are so much increased as to render the track extremely dangerous for trains unless discovered in time and repaired.

Too much space at the joints also affects the wearing qualities of the rails, the openings at the joints being so large that the wheels batter their ends, and they wear out and have to be taken out of service much sooner than would be the case with rails of the same quality if laid with the proper spacing.

The table to be used for securing the proper space for expansion is given in Chapter VIII under "Allowance for Expansion."

Expansion shims should be made of narrow, flat iron or steel, and bent so that one end will rest on top of the rail when in place. The shim can thus be easily removed and used again after a piece of track is laid, and all the bolts then tightened up on the joint fastenings.

A ten-penny common steel nail, if bent at right angles, makes a cheap and handy expansion shim when no others are provided. It may be used at almost any temperature above the freezing point, by reversing the end and flattening the head of the nail. Expansion shims should not be allowed to remain between the ends of the rails after a piece of track has been laid and the joint fastenings made secure.

When laying old rails make the same allowance for expansion as when laying new ones.

Creeping rail. Aside from the movement of the rail due to expansion and contraction above referred to, it is very likely to be moved by the wave motion which exists when the wheel passing over a track comes in contact with the rail; the rails are shoved ahead, on double track with the current of traffic, and on single track usually in the direction of the heavier traffic, but if there is a heavy grade the track may move down grade with the direction of the lighter traffic. This force is often great enough to pull the slot spikes and move the joints ahead of the joint ties, and ties are slewed around and shoved ahead with such force as to churn up the ballast ahead of them. As a result, the rails are crowded ahead and the space allowed for expansion on account of temperature is all closed up perhaps pulling apart a joint just as would occur in case of contraction in severe winter weather when the proper spacing has not been made in laying the rails as above explained.

To counteract this effect it is necessary to apply anti-rail-creepers or "rail anchors" as they are called. There are a number of good ones on the market today such as the P. & M., the Vaughan, the Dinklage Creep-check, etc., shown and described in Chapter IX.

The number of rail anchors necessary is something that varies with the particular conditions. The diagrams following show the manner in which they

should be applied and the number used to resist the creeping. Where the tendency to creeping is light two per rail may answer the purpose, four where medium, and six per rail where heavy creeping is encountered.

Unloading and loading rails. To avoid damage to rails by dropping them on hard ground or ballast it is best to unload them by derrick or other mechanical means. The American Rail Loader, shown in Fig. 2, is an excellent machine for this work. It can be run on its own wheels over a string of flat cars and the rails picked up by means of a clamp which is readily fastened to the rail near the center, the operation being by a long air cylinder supplied with compressed air from the train line, the operator simply turning a valve to raise or lower his load as desired. Only a small force of men is employed when handling rails in this way, one to operate the machine and six others, three in a car to get the rails ready and adjust the clamp, and three on the ground to move the boom, land the rail and remove the clamp. To handle rails in this way requires, of course, a work train or engine to supply air. The boom is so designed that when the flat car upon which it is located is coupled to a gondola car the clamp will come right for the center of the car and rails can be loaded or unloaded as readily from this class of car as from a flat car. In loading up flat cars, the rails can be piled up as high as desired and the car loaded to its capacity, which is hardly possible, or at least not a safe practice, when the loading is done by hand. In loading or unloading a car an average of a rail per minute can be maintained, and if flat cars are being unloaded the machine can be moved forward by the men and placed on the car just emptied; if gondola cars are used, the one loaded or unloaded must be switched out and replaced by another.

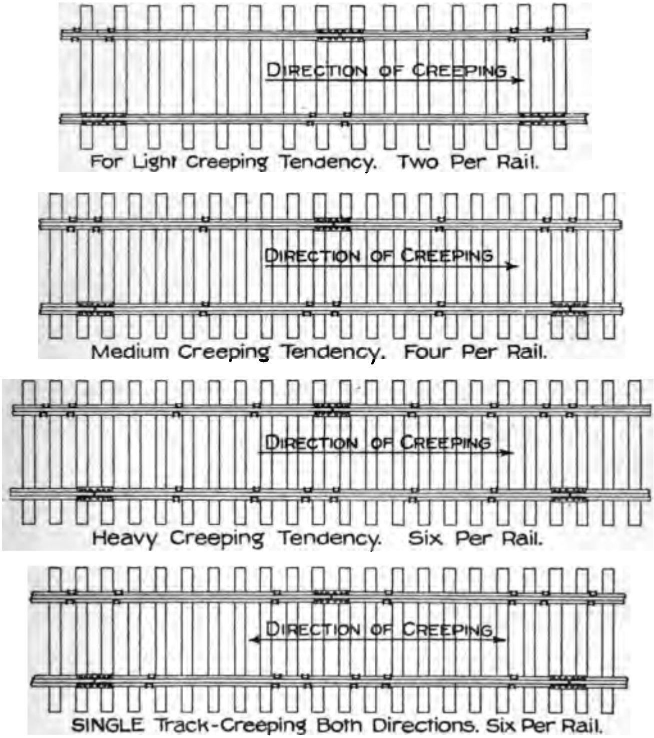


Fig. 1. Proper Location for Anti-Creepers

Short rails for curves. The usual practice when an order is given by a railroad company to furnish a certain tonnage of rail is to specify the length of rails desired, 30 ft. or 33 ft. as the case may be, and to accept up to ten per cent of the tonnage in short rails, down to 25 ft. lengths, diminishing by one foot successively. Some of these short rails are used on the in-

Fig. 2. American Rail Loader

side rail of curves in order to keep the joints broken with the other rails on the outside line. What extra ones are not required for this work should be kept together and used up on straight track, breaking joints to the best advantage.

When laid in a sag. When a piece of track is laid in a sag which it is intended soon to raise to grade, the rails should be laid with open joints and the

splices loosely bolted, otherwise, when brought to grade the joints will become too tight, since a sagging track is longer than one which is laid accurately to grade.

Change of line toward center of curve. In cases where the general change of line is made by moving a curved track inward several feet, dig out the material which is used for filling between the ties for the full distance covered by the change in line, so that the ties will not crowd against each other or injure the surface by rising up. Before commencing to line, cut the track loose at the middle of the curve by removing the joint fastenings at one joint on each line of rails as nearly opposite as can be selected, and loosen the spikes from at least one line of rails between the joints thus cut in order to permit the two broken pieces of track to move independently of each other. Start lining gangs at one or both ends of the curve and work towards the middle, moving the track towards the new line 12 to 20 inches, or as far as it can be pulled conveniently with one lining, without kinking the rails or splices. Continue thus until the opening in the middle of the curve is reached. Then go back and commence again as near the end of the curve as may be necessary, and work towards the middle as before. Repeat this process until the inside rail of the track has been moved beyond the center stakes for the new line, bringing in both ends of the curve alike. Then, while part of the men are spacing and squaring the ties, throwing in surfacing material, etc., go over the ground with a small gang and line the track to the center stakes. Do not cut the rails to fill up the opening at the middle of the curve until all the lining of the track is finished; otherwise the rails may not fit after all the lining is completed. Lining from the ends of the curve toward the middle always forces the track to move

forward toward the opening when throwing track inward. By moving the track a little past the center stakes with the first lining, if the curve is being moved in, and then throwing it outward to its place when finishing the work, buckling or jamming joints together is prevented and the track is made less difficult to handle. The latter operation stretches the track, and opens up joints that might otherwise have proved too tight for conveniently maintaining a good line in the future. If the section of track to be thrown is long, and particularly if of heavy construction, it may be necessary to cut the track at more than one place.

When the change of line is so great that the new line is some distance clear of the old track, it is sometimes a better policy to lay a new section of track throughout than to try to move the old piece of track to place with lining bars.

Making connections. When laying rails on either main or side tracks never make a connection with a piece of rail shorter than ten feet. When you see that only three or four feet of rail are necessary to connect the ends of a piece of track, add the three or four feet to the length of the rail immediately adjoining the space, cut two pieces of rail half the length of the total number of feet, and put these into the track to make connections. A piece of rail less than ten feet in length is of greatest value to the railroad company when returned to the rolling mill. Except in cases where it is absolutely necessary to use short pieces of rail, as at the ends of frogs in round house tracks, they should be avoided. Modern round house design nowadays generally requires the elimination of frogs between the turntable and house. A track foreman can generally avoid making a short connection, especially when laying old rails, by cutting lengths of rail from 26 ft. to 33 ft. which are battered

on the ends but otherwise in good condition. When rails of different length are at hand a great deal can be accomplished by doing a little figuring to make such a combination of length of rails that an opening can be closed without cutting at all.

Lining new track. When a new road is first laid out the engineers set stakes where the center of the track should be. These are generally 100 feet apart, and a tack is driven in the top of each stake to show the correct center of the track. The man whose business it is to line the rails behind the tracklayers always carries with him a small light wooden gage on which the center is marked. The manner of lining new track is as follows: The trackliner places his gage on top of the rails across the track over one of the center stakes. His men then lift the track to one side until the center mark on the gage is directly over the tack in the top of the center stake between the rails. This part of the track is then allowed to remain in that position and should not be moved again. After the trackliner has put the rails in position at two or three center stakes, he proceeds with his men to put the rails between these points in a true line with them, which completes the work. Any carelessness on the part of the trackliner in the matter of putting the rails in their proper place at the center stakes is apt to cause trouble when the track has been surfaced, as it is often difficult for the trackman in charge of a section to get a perfect line on his track at places where the first trackliner left swings in it, because often many of the center stakes are lost or moved out of position during the work of tracklaying.

The steel car should be light, strong and compact, and made of the best material, so that it can carry a heavy load and at the same time be easily handled by the crew working it. The wheels' tread should be at least eight inches wide, so that the car can pass over

loose and unevenly gaged track without leaving the rails. A car load of rails off the track may cause considerable delay.

The gage used to hold the rails in place ahead of the steel car should be made of one solid piece of iron with a flange to come down on both sides of the ball of each rail. This kind of gage serves the double purpose of gaging the track and of holding the loose rails in place until the car has passed over them.

When spiking new track the foreman should see that the gage is not placed too far away from the joint when the spikes are being driven; otherwise, if the loose end of the rail is bowed in or out, the gage will be wrong.

Forwarding material. In constructing a new line the material used must necessarily be hauled out to the point of construction. The center of activities is at the end of the completed track, hence it is of the utmost importance that only what is required to keep the work in progress continuously be forwarded. To avoid accumulation and all interference, this distribution should be in charge of a competent man who will keep in close touch with the general foreman and find out just what is desired from day to day and have it loaded up at the material yard, which is the center of distribution; or, if the material be on cars, shall see that the proper cars go forward switched out in the proper order. If the track laying gang is continuously using the stub end of the track as fast as it is laid during the day for the operation of the steel car, and it is not convenient to distribute ties ahead by means of teams without interfering with the work of tracklaying, it may be necessary to have the distribution of ties made at night.

Ballast gang. This should follow up the tracklayers as closely as can be arranged so that there will be no interference with the distribution of material

either for the track layers or with the unloading of ballast. A gang of forty men should keep this work advancing properly and be able to furnish the help required to distribute the ballast if furnished in self-clearing cars. The composition of this gang will be approximately the same as the one referred to in detail in Chapter VII on "Ballasting."

Force required for track laying.

1	Foreman ....
2	Assistant Foremen ....
2 to 4	Tie Spacers—Space ties ahead of new rails........
2	Tie Gagers—Mark location of rails on ties before rails are laid and assist tie spacers in locating joints, ties, etc. ....
1	Gageman—Handles gage for spiking track to gage ahead of steel car ....
4	Spikers (head)—Spike every third or fourth tie ahead of steel car ....
2	Tie Nippers (head)—Hold up ties for head spikers..
8 to 12	Tongmen—Unload rails from steel car and place in position for spikers ....
1	Shimman—Carries box of assorted shims and places proper shim for expansion ....
8	Bolters—Apply joint fastenings ....
8 to 16	Spikers (back)—Spike every tie not finished by head spikers ....
4 to 8	Tie Nippers—Hold up ties for back spikers ....
6	Material and Toolmen—Distribute joint fastenings, spikes and bolts, and look after tools ....
2	Water Carriers—Supply force with drinking water..
51 to 69	Men in entire gang.

NOTE:—Above does not include force required for distribution of ties.

A machine for handling rail and track material. The Brown Rail Loader is mounted on a covered 34-ft. flat car of 60,000 lbs. capacity. It consists of a 22-ft. demountable boom attached to a low mast and guyed to an adjustable "A" frame on each end of the car. The hoisting cables run along the booms, through the masts, around drums, and are then attached to

the rods of the pistons in the compressed air hoisting cylinders. These cylinders are placed longitudinally on the floor of the car and each is equipped with a three-way valve lever or chain control enabling the operator to occupy any position in the car while raising or lowering loads. In order to draw air for the device from the "Train Line" without cutting out any of the cars in the train, two compressed air reservoirs are provided under the car and connected with each cylinder. The housing between the boom masts has sufficient door and window openings and is made long enough to accommodate the booms so that when not in use they can be placed in the car and locked.

The loader is built in two types: (A) 2,200 lbs. capacity with a compound lift of 12 ft. (B) 2,200 lbs. capacity with a compound lift of 24 ft. and 4,500 lbs. capacity with a straight lift of 12 ft. The change from 2,200 lbs. to 4,500 lbs. in type B is made by releasing the cables from the drums, a clamp of simple construction being the only attachment required.

Some of the advantages claimed for this machine by the manufacturers are: (1) The material is handled without being damaged. (2) Danger of personal injuries is greatly reduced. (3) A much smaller force of men is required for the work. (4) A considerable saving in time required to handle a given amount of material, which is of special importance in handling material on main tracks, and (5) A great saving in cost of doing the work.

In loading or unloading rail by hand a force of about 40 men with foreman and sub-foreman is required. The wages of such a gang will amount to approximately $85 per day of 10 hours. If the work is done with a Brown Rail Loader and is carried on at the same time on the two cars coupled to it, the makers claim that the force required will consist of

two men on each car for swinging the rails into place and straight with the car and for loosening or attaching the cable clamps to the rails, two men on the ground opposite each car for attaching the cable clamps to the rails and swinging the rails parallel to the car, or for swinging the rails parallel to the track, properly spacing them and loosening clamps if rail is being unloaded. An operator to manipulate the machine and a foreman complete the force, which will cost about $22 per day of 10 hours. These figures show a saving of about $63 a day for labor resulting from the use of the machine. The amount actually saved will, of course, be less than indicated, as interest on the cost of the machine, maintenance, depreciation, taxes, cost of oil, grease and waste, cost of compressing air, depreciation and maintenance of all compressed air equipment involved, oil, grease and waste for such equipment, and cost of handling the machine in the work train, and from one piece of work to another must be deducted from the $63 saved through reduced labor cost.

The rate of speed at which the machine may be operated is claimed to be four to five rails per minute with the train moving at the rate of two miles per hour. On the Boston & Maine R. R. five high side cars containing 160 tons of rail were unloaded and set up for laying in 3 hrs. and 15 min., which includes time taken to clear the main track for three trains. The Boston & Albany R. R. accomplished on June 6, 1912, 99 95-lb. rails handled in 50 min. using only one end of loader. Illustrations of work performed with Brown Rail Loaders on the New York, New Haven & Hartford R. R., are:

July, 1913, 625 100-lb. rails handled in 4 hrs. and 30 mins., using only one end of loader.

July, 1913, 53 100-lb. rails handled in 17 mins., using one end only.

The amounts of time stated in these records include the time necessary to clear the track for other trains.

Tracklaying by machine with treated ties. It is difficult to lay track with a track laying machine when treated ties are used. A report on this work by E. E. Roos, Superintendent of Track on the Pecos & Northern Texas Ry., states that in using ties right from the treating plant, the dripping oil made them

Fig. 3. View of Brown Rail Loader Ready for Operation

slip badly when carried forward on the rails. As the carrier for the ties is above the carrier for the rails the oil dripping on the rails gets them in a greasy condition, making it hard for the machine to grip the rails and frequently breaking the driving chain.

Cost of track laying with a track machine. A large job of track laying is described in the April 1, 1914, issue of Engineering and Contracting, as follows: Every device or appliance which would help along the work was furnished. Tools and machinery were maintained at top efficiency through frequent expert attention. Years of experience have developed a construction organization of enviable efficiency. It is not surprising, therefore, that the costs appear exceedingly low, as compared with track laying by railway company forces. The costs given do not include

unloading the material in the material yard, loading it into the distributing train, nor transporting it to the "front."

One of the most vital reasons why contractors turn out cheaper work than railway companies is the fact that they offer better wages and thereby get better laborers in the end, as the weeding out process is available when good wages are paid. Also, stipulations are usually introduced into contracts which make the owner liable for extras in case the contractor's work is held up or interfered with. Consequently, great efforts are made to keep the contractors' force fully supplied with material and room to work in.

Make-up of track laying machine train. When laying track, the train carrying the machine is made up as follows, beginning with the "pioneer car," which always remains at the "front," and is not changed out as are the other cars in the train. Immediately behind the "pioneer" are four cars of rails, then the locomotive, and behind that eight cars of ties; next comes a car of tie plates, when they are used, the "trailer," which is a car carrying spikes, bolts and base plates, a car of plank for crossings, a car of cattle guards, a tool car and the way car. This makes twenty cars, and all are flats except the two last mentioned.

The first car of rail behind the pioneer is "trimmed"; that is, on it are loaded angle bars enough to lay the amount of steel carried on the train. The angle bars are carried forward over the pioneer car and delivered as needed to the "strap hangers" in front. The rails underneath the angle bars are the last ones laid from the train, in order that the angle bars may be cleared off by the time rails are needed.

A system of trams is used to carry the ties and rails to the front. The trams are made in sections, each 33 ft. long, the sides consisting of 2½ by 10 in. planks.

Tie trams are 14 in. wide, and rail trams are 12 in. wide. The trams are held together by bolts on which are pipe separators to hold the sides the proper distance apart. Near the bottom of the trams are live rollers, which complete a trough-shaped way for ties or rails.

On the pioneer car is installed a 20-h.p. upright engine for driving the live rollers in the trams; this is done by means of a tumbler shaft and gear or cog wheels. Steam for the stationary engine is piped from the locomotive. The shaft is fitted with patent couplings, consisting, on one end of each section, of a casting containing a square socket into which the end of the next rod fits. Each length of tram has a section of the shaft bolted to it and as the trams are hung the rods are fitted together, thus forming a continuous shaft. The trams are " hung " on iron brackets or trusses which hook into the stake pockets on the cars. The trusses are made with flange rollers on which the trams are placed, thus taking care of the slack of the train in starting and stopping. The trams have a coupling device which holds them together, the ones on the pioneer being permanently fastened to the car.

The tie trams, 660 ft. long, are operated on the right hand side of the train. Those for the rail, 240 ft. long, are on the left. The movement of ties and rail is controlled by the "dinkey skinner," i.e., the stationary engineer, so as to deliver them in front of the train as needed. A tie chute, 53 ft. long, provided with dead rollers, is attached at the front end of the tie tram on the pioneer, and through this chute the ties are pushed by the ones coming forward over the live rollers. As fast as they are delivered at the end of the chute they are taken by the "tie buckers" (laborers) and are placed across the grade ready for the rails.

A similar chute attached to the rail tram provides a way for delivering the rail in front of the pioneer. These chutes are supported at the outer end by cables attached to the rear end of the pioneer car and carried up over a high frame work or "gallows" on the front end. A boom, also attached to the front end of the pioneer car, extends far enough ahead to have the cable attached to it reach the middle of the rail when placing it in position in track. This cable is operated by hand with an ordinary crab. Instead of cranks, a light buggy wheel is used by the operator to wind up the cable, which lifts the rail and holds it while the "heeler" and his assistants place it in position on the tracks. (A newer device handles the cable with compressed air.) The rails are placed in the trams by three men and are handled in front by six more. One man on each car places the ties in the trams. The spikes, bolts and base plates are peddled from the trailer as the train proceeds.

The rails are held to gage by bridle rods until the train passes over, all spiking being done in the rear. The train moves ahead one rail length at a time when laying square joints, and half a rail length when laying broken joints. The trams are taken down when cars are empty and replaced on the loaded cars when a new train arrives. From 100 to 125 men are required for a full crew.

Material for the track machine is loaded by railway company forces, and great care is taken to have the material loaded, not only in correct proportion, but in correct order and position on cars. A train called the "swing train" is then made up of sufficient material for a half day's work, and is transported to the front, or rather to the camp of the contractor, where it is placed in the most convenient place available for the track machine crew to pick up. The swing train crew then takes a train of empties and re-

turns to the material yard. The track machine is served regularly by the same locomotive and train crew. As the track machine does not move ahead by its own power a locomotive and train crew are required to remain with the machine constantly.

Briefly, the movement of the machine is as follows, in laying square jointed track: ties are trimmed and carried ahead constantly and laid on the grade; the machine moves ahead, and a rail is chuted out and heeled in by the rail gang, and the angle bars bolted on loosely with two bolts only; a second rail is placed and held to gage by bridle rods; the machine is then moved ahead a rail length by the locomotive, and the operation repeated.

Back of the machine the bridle rods are removed, and enough ties are spiked to hold the rails from spreading. Spacing ties, bolt tightening and full bolting are all done behind the machine and cause it no delay.

Organization of gang. A gang of 127 men will easily lay two miles of track per day, provided no unusual difficulties, such as soft grade, etc., are encountered. A gang of this size would be placed about as follows:

1	general foreman, per day	$ 5.00
1	ass't foreman, with rail gang, per day	3.50
1	ass't foreman, watching trams, per day	3.50
1	ass't foreman, with spikers, per day	3.50
1	ass't foreman, lining track, per day	3.50
1	stationary engineer, per month	75.00
1	pole man, per month	75.00
1	oiler, per day	2.50
1	line man, per day	2.25
16	"tie buckers," per day ...$2.25 and	2.50
2	tie spacers, ahead of machine, per day	2.25
1	man fiddling ties, per day	2.25
6	"rust eaters," handling rail, per day	2.50
1	bridle man, per day	2.25
1	heel nipper, per day	2.25

2	strap hangers, per day	$ 2.25
1	man, carrying angle bars from "trimmed" car to pioneer car, per day	2.25
3	steel rollers, rolling rails into trams, per day	2.50
8	tie trammers, rolling ties into trams, per day	2.25
2	spike peddlers, distributing spikes, per day	2.25
2	bolt and joint plate peddlers, per day	2.25
2	"bridle men," carrying bridle rods from rear, per day	2.25
4	rear bolters, per day	2.25
2	water boys, per day	2.25
8	men spacing ties, per day	2.25
1	gage man, per day	2.25
32	spikers, per day	2.50
16	nippers, per day $2.25 and	2.50
8	liners, per day	2.25
127		

When the gang is smaller, the force behind the machine is cut down, and 74 men would be organized about as follows:

1	general foreman, per day	$ 5.00
1	ass't foreman, with rail gang, per day	3.50
1	ass't foreman, watching trams, per day	3.50
1	ass't foreman, with rail gang, per day	3.50
1	ass't foreman on general work, per day	3.50
1	stationary engineer, per month	75.00
1	pole man, per month	75.00
1	oiler, per day	2.50
1	line man, per day	2.25
10	"tie buckers," per day $2.25 and	2.50
2	tie spacers, per day	2.25
6	rail handlers, per day	2.50
1	bridle man, per day	2.25
1	heel nipper, per day	2.25
2	strap hangers, per day	2.25
1	man carrying angle bars, per day	2.25
3	steel rollers, per day	2.50
8	tie trammers, per day	2.25
2	spike peddlers, per day	2.25
2	bolt and point plate peddlers, per day	2.25
1	bridle rod man, per day	2.25
2	rear bolters, per day	2.25
1	water boy, per day	2.25

1	gage man, per day	$ 2.25
4	men spacing ties, per day	2.25
12	spikers, per day	2.50
6	nippers, per day	2.50
74		

During the work from which the cost data were obtained, the gang varied from about 50 to 100 men. The $2.50 laborers (spikers, nippers, and tie buckers) averaged about 40 per cent of the entire gang for the 65 days worked. The following expenses were chargeable against track laying:

Overhead charge on machine (interest at 6 per cent, depreciation at 10 per cent)	$ 100.00
Dinkey skinner at $100 per mo.	210.00
Timekeeper at $85 per mo.	177.00
Locomotive and crew, 65 days, at $40	2,600.00
Supervision and labor	8,710.00
	$11,797.00
Force account, or extras allowed	578.00
	$11,219.00
Average cost per mile	$280.50

This cost represents the cost to the contractor, plus the cost of the locomotive and crew at $40 per day. The latter charge should be added, however, as it represents a real part of the operation expense of the track machine.

The general track conditions. The organization of a force working on a track laying machine is easily adjustable to the amount of laborers at hand, within certain limits, by a foreman who is competent. When a full crew is not available, the man in charge will cut out certain parts of the work, such as full spiking and bolting behind the machine, reduce the number of the "tie buckers," viz., men carrying ties, to the minimum, take off the lining gang from behind, and so on all through the entire crew wherever a man can

possibly be spared, leaving only those laborers whose work is absolutely necessary to be done while the rail is being laid. The rest is left to be done on the "back work." The two methods given above illustrate this. Occasionally a crew becomes so small when men are scarce, that only half of a train will be laid in a half day. This is expensive for the contractor as it generally necessitates "taking down" and "hanging" the trams an extra time for a mile of track.

When a full crew is on the work a mile of track can be easily laid in from three to four hours, including hanging and taking down the trams.

The track, from which the cost of track laying above was computed, was laid during the winter months, and some bad weather was encountered, but the work probably progressed as fast as it would in the summer months, when extremely hot weather is likely to slow up the men.

The rail used was the standard length 33 ft., laid square joints on tangents and broken joints on curves. When a curve was reached a rail was cut to break the joints, the cut being figured so that the short part was used on the inside of the curve at the start, and then the long part was used at the end on the outside of the rail of curve to square the joints for the tangent. The specifications stipulated that joints must not be laid within four feet of the ends of bridges and culverts. To avoid cutting rails to meet this condition, fractional steel (short rails) was loaded on the "trimmed" car, and when approaching a bridge the distance was measured, and if found necessary a panel or more of these short length rails would be used to bring the joints the desired distance from the end of the bridge. In laying through yards where sidings were located, the main line was laid through regardless of the switches, and when switches were put in they were laid as near to the engineer's loca-

tion as they could be put without cutting a main line rail. The fractional steel, a certain amount of which all companies agree to take with every large order for rail, was laid between the switches on the main lines through station grounds. As a rule the sidings were all laid with released rail, the work being done by hand.

The rail was of 90-lb. section laid on white oak ties, spaced 18 to 21 under a 33 ft. rail on tangent, and 19 to 22 on curves. The joints were made with ordinary angle bars with four bolts, and spring nut locks. The heads of the bolts were staggered, that is, alternate bolt heads were respectively on the inside and outside of rail. The number of ties per rail length was varied to suit their sizes, i. e., 18 broad faced ties being used, or 21 narrow faced ties, on tangents.

The cost of transporting the machine and the men to the work is not included herein, the data given representing the costs after the machinery and the laborers were on the work.

An inspector was employed by the company, but although his expenses represent a charge against the track by the railway, it is not chargeable against the contractor's expenses.

A labor saver for unloading rails from end door box, stock or coal cars. The following notes are by Mr. F. L. Guy.

Frequently steel rails are shipped from the mills in end door box, stock or coal cars, and for railroads in the West this is very often the case. This is caused by the scarcity of flat cars, or to save back haul on empty cars. Thousands of stock cars are shipped into Chicago from the West every month, and there are not many articles that can be loaded in these cars for the West. A large number of railroads in the West utilize these stock cars for rail.

To unload rails for relaying from flat cars is a

simple proposition. The car stakes are taken out and the rails are pinched off the sides of the cars with pinch or lining bars. When the rails are pinched off they fall on the shoulder of the roadbed and no further handling is necessary except to butt them against the rail that has been thrown off before. There are necessary for this work about eight men on each side of the flat car and about as many men on the ground.

To unload rails from box, stock or coal cars is a very different proposition. It is necessary to have two ropes about 50 ft. long. On one end of each rope a ring about 3 in. in diameter is fastened, and on the other end is a hook made from ½ or ¾-in. round iron with a square turn. This hook must be small enough to go into the bolt holes of the rail that is being unloaded.

A man is stationed on each side of the track about 50 ft. from the end of the car. Each man has a lining bar, and they jab their bars down between the ties and then drop the rings on the ends of the ropes over the tops of the bars and let the rings drop to the ground. The hooks on the other ends of the ropes are then inserted into the bolt holes of two rails, one on each side of the car. The car is then moved ahead, and the rails into which the hooks are fastened slip out of the car and fall in between the track rails. Men are then assembled around the two rails which have just fallen, and throw them out on the shoulder of the roadbed.

The device which is shown by the accompanying sketch (Fig. 4) is to throw the rails out on the shoulder when they come out of the cars. It consists of a light rail say 48 or 52 lbs. about 10 ft. long, and two pieces of 1 x 3-in. by 4-ft. strip iron. The rail is bent into an A shape and the ends are turned up a little to check the fall of the rail that is being un-

loaded. The strips of iron are bolted to the web of the rail about $1\frac{1}{2}$ ft. from the apex to balance the A-frame and keep it away from the end of the car. The strips should be bent upward and should be so turned as to get a good bearing against the bottom of the floor of the car. The ends of the A-frame should extend about $3\frac{1}{2}$ ft. from the end of the car. This is to keep the rail which is being unloaded from jumping over when it falls out of the car.

The men with the bars should place them on the outside of the track rails, as near as possible to the ends of the ties, and when the car is moved ahead the ends of the rails in which the hooks are fastened will

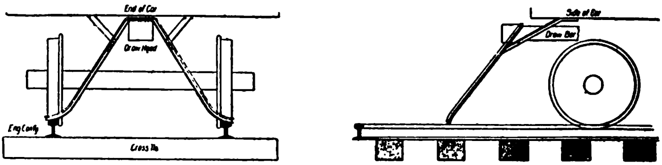


Fig. 4. Device Used in Unloading Rails From End Door Box, Stock or Coal Cars

fall to the ground on the outside of the track rails. When the other ends of the rails slide out of the car they will fall on the A-frame and slide down and fall outside of the track rails on to the shoulder, where they will be out of the way.

This device saves the work of about eight men, as the rails do not have to be lifted out from between the track rails, and it also saves time for the entire crew, as they do not have to wait until the rails are taken out of the way. The design of the strips can be varied to suit any make or class of cars. They can also be shifted up or down the A-frame to suit local conditions. When one car is unloaded the A-frame can be lifted off and placed on another car by four men and very little time is lost.

This device in about this same form has been used on the Atchison, Topeka & Santa Fe Ry., Eastern Lines, for some little time with considerable success.

List of track tools for maintenance. After the construction of a new road, the following tools will be required for use on each section.

Kinds of Tools	For gangs composed of foreman and 6 men	4 men	2 men
Adzes, with handles	2	2	2
Axes, chopping, with handles	1	1	1
Ballast template	1	1	1
Ballast forks (stone ballast sections)	4	2	0
Bars, claw	3	2	2
Bars, lining	6	4	2
Brooms, common	2	2	2
" rattan	6	4	2
Cans, oiler for hand car	1	1	1
" one gallon oil	1	1	1
" five gallons oil	1	1	1
Cars, hand	1	1	1
" push	1	1	1
Chain for locking	2	2	2
Chisels, track	6	6	6
Cups	1	1	1
Funnels	1	1	1
Grindstones	1	1	1
Handles, extra for adze	1	1	1
" " " axe	1	1	1
" " " picks	6	4	2
" " " sledge or spike maul	1	1	1
Hand axe	1	1	1
Hoes, scuffle (gravel section only)	6	4	3
Jacks, Track #1	2	2	1
Kegs, water 15 gal.	1	1	1
Lanterns, white complete	4	3	2
" red "	4	3	2
" yellow "	4	4	4
" green "	2	2	2
Lantern Globes, white	2	2	2
" " red	2	2	2
" " yellow	2	2	2

Kinds of Tools	For gangs composed of foreman and 6 men	4 men	2 men
Lantern Globes, green	2	2	2
Level, track	1	1	1
Mauls, spike, with handles	4	3	2
Picks, common	6	5	3
" tamping, stone ballast sections	6	5	3
Pliers, wire	1	1	1
Post hole digger	1	1	1
Punch, track, round with handles	1	1	1
Rakes, on gravel sections	1	1	1
Saw, hand	1	1	1
" crosscut	1	1	1
Scythes, briar or grass complete	6	5	3
Shovels, track	7	5	3
Signals, flags, red	3	3	3
" " green	3	3	3
" " yellow	3	3	3
Sledge, 14 lbs. with handles	1	1	1
" 8 " " "	1	1	1
Spike puller	1	1	1
Tape line, 50 ft.	1	1	1
Torch	1	1	1
Torpedoes	40	40	40
Track gages	2	2	1
Whetstones	6	5	3
Wire stretcher	1	1	1
Wrenches, Monkey, 14″	1	1	1
" Track	7	5	3
" Switch (2 sizes)	2	2	2
Wire, telegraph (100 ft. coil)	1	1	1

Force required for double tracking. The following notes were published in Ry. Eng. & M. of W.

"The proper distribution of laborers is dependent on class, size, and weight of material, as well as on the class of labor employed. Individual opinions and methods of foremen also cause differences in distribution of men. After a grade has been completed and the ties lined and spaced approximately, a gang may be organized as follows, subject to the supervision of one foreman and one assistant:

Tie fiddler 1	Spike and bolt peddler.... 1
Tie spacers ....2 or 4	Spikers 12
Steel gang 12	Tie nippers 6
Rail nipper 1	Gage liner 1
Strap hangers 2	Back bolters 2
Strap tighteners 2	Tool man 1
Joint plate peddler 1	Water boy 1

"*The tie fiddler* is provided with a fiddle, i.e., a short board with a cleat nailed on it at right angles near one end. The distance from the inside edge of the cleat to the end of the board is the standard distance for the rail base from the end of the tie. This fiddle is held on the face of the tie with the cleat securely against the end, and a mark made on the tie along the uncleated end of the fiddle. The outside track spike should be set on this line when spiking. Before marking a tie, the fiddler should examine it, and be sure that the bark side is up. The tie fiddler will generally be able to run ahead of the gang without difficulty. He should also set the tie line. For this purpose it is handy to have a board of such a length that if one end is placed against the ball of the rail in the old track, the opposite end will show the proper line for the new track ties.

"*Two tie spacers work behind the tie fiddler.* They are provided with a rod of the same length as the rail which is to be laid. The marks for tie centers for one rail length are marked off on the rod, which is laid on the ground with the rear end even with the head end of the last rail laid. This rod should be used on the line side, as the line rail is set up first. Picks are generally used by the tie spacers in dragging the ties to center. The pick point (if pick is used) should be stuck in the end of the tie and never in the top or side. When spacing ties the man on the line side pulls the ties to the line (previously stretched), and the man on the gage side places the end of his tie so that it lies square across the

grade. The tie spacers must space ties for a full rail length while the steel gang is setting up two rails. Possibly four tie spacers may be needed in some cases in order not to delay the rail gang. The spacers must also inspect all joint ties, and if they are deficient in size or quality, they should be exchanged for those of better grade. In lining ties they should not be pulled up against the tie line, but should be left about ¼-inch away. If the ties are allowed to touch the line, some of them are bound to throw a kink into it. If broken joints are being used in the track, the work of tie spacing is increased. Several ties near the middle of the line rail will have to be shifted in order to fit the joint slots on the gage rail.

"*The rail gang* picks up the rail, sets the rear end on the ties, at the same time entering the rail ball into the angle bars hung on the rail previously laid. The head end of the rail is dropped at a word from the heeler, and this movement throws the rail into proper position in the angle bars. The heeler now gives the command 'heel,' and the rail is pulled backward against an expansion shim, inserted between the ends of the rails. In setting up the line side the assistant foreman should see that the rail is set as near as may be to its correct line, as shown by the fiddled chalk marks on the tie. The gage rail should also be placed approximately in correct position. For this purpose a light wooden gage can be used; if none is furnished, one may be easily made with a board and a couple of blocks of wood. If the rails are set up as described, scarcely any ties will have to be lined up by the line spikers; the work of the gaging spikers is also reduced to a minimum, and the track when finished will be approximately in correct line, so that work is saved the lining gang as well as the spikers.

"In order to facilitate setting up a rail and putting it in its proper place in the angle bars, a 'nipper' is provided. He carries a bar to raise the angle bars or rails as necessary.

"*The strap hangers* use short handled wrenches, these being handier and permitting faster work than long handled ones. The latter are not necessary as the strappers are required only to start the nuts, and not to tighten them. When a rail is set up, the strapper hangs a pair of angle bars on the head end. As the next rail is heeled into place he puts in a bolt through the rail being placed, and after giving the nut a few rapid turns, goes ahead and repeats the operation. Two bolt tighteners follow, and tighten the nuts which the strappers have started.

"*The joint plate peddler* places the joint plates under the rail in the proper position for spiking. The spike and bolt peddler distributes four spikes for each tie, and enough bolts and nut-locks at each joint to finish bolting in full. These two men should work together and help each other out whenever necessary.

"Before spiking a tie, the nipper on the head gang of spikers should see that the outside of the base of rail is nearly in line with the chalk line marks on the ties. If it is not in line, he should move the rail over approximately to line with his nipping bar.

"*The outside line spiker* sets the outside spike on the fiddled mark, and gives it one heavy blow with the spike maul. The nipper then raises the tie up against the rail with a bar, using as a heel the nipping block. The operation shoves the ties over until the line spike sets snugly against the rail. The inside spiker then sets his spike, and both spikes are driven. The spikers work in six gangs, three on each side of the track. The head gang spikes every third tie, the

second gang takes the tie just behind it, and the third gang spikes the remaining tie. The rail, when spiked, should have a solid bearing. If the face of the tie does not afford a good even bearing, the gage spikers must adze off the part of the tie beneath the rail, so that a good bearing is assured. In having the gangs spike every third tie there are the following advantages: (1) Twelve to 16 spikers may be kept working in a distance of 60 feet or less, and being close together, allow easy supervision by the foreman. In the older method—i.e., each gang spiking a rail length in full—the spikers frequently become scattered over a distance of 200 to 300 feet. Spikes should be driven perpendicularly and uniformly on the corresponding edges of the ties and to accomplish this it is necessary to have the men close enough together so that the foreman can easily watch each man; (2) Any gang of spikers must do as much work as the head spikers, or fall behind, since the gangs are spiking tie for tie. It is easy in this manner to discover an unwilling or incompetent man; (3) By putting the best gangs in the lead on each side of the track a greater amount of work is accomplished. The back bolters bolt the joints in full and turn up each nut as tight as possible. Back bolting requires little skill and only ordinary strength; this is a good place to start in green or inexperienced men.

"*The tool man is one of the most important men on the gang.* If a good trustworthy man is selected he may save the foreman much responsibility. He is held accountable for the number of tools on the work each day, and also for the tools in the tool boxes. The condition and supply of tools can be left entirely with him; in case any are in bad order, it is his business to exchange them for good tools; if necessary he must use his own ingenuity in repairing those on

hand or in 'borrowing' from other gangs. A live tool man will be on the lookout and know when new tools arrive on the job, and thus be sure of obtaining his share. Although little hard work is required, a tool man should be chosen who is industrious, reliable and intelligent.

"A very handy way of taking care of tools and surplus material, in double tracking, is to have a push car on the track which is being built; the tool boxes are kept on this car. The tool man shoves the car along as the work advances; he takes out the shims and picks up all scattered tools and light track material, loading them on the car. In this manner excess tools and materials are convenient for emergencies.

"*When setting up rail,* the assistant foreman has charge only of the steel gang, strappers, tie spacers, and the fiddler. If these men are able to run far ahead of the spikers, setting up rail can be discontinued and the rail gang organized into spikers, bolters, etc. The assistant foreman is responsible for proper expansion in the track and must be careful to use a uniform thickness of shim.

"The foreman will generally have to instruct his assistant as to the proper thickness of shim to use, and when to change to a thicker or thinner size. The temperature of the steel is what should govern, and not the temperature of the air. The temperature of steel, in general, lags below the air temperature in the morning, and loses its heat less rapidly than the air in the afternoon. If a subgrade is rough and uneven a greater allowance should be made for expansion, as the track will shorten when brought up to surface. The track laid should be lined at the end of each day to prevent shortening. The track laid in one day will move ahead when the short kinks are lined out, but

if lining is neglected for several days the weight of the track becomes too great to move ahead, and all lengthening caused by kinks being straightened will be made up by a decrease in the expansion.

"In case the number of men is too small to organize completely for all the necessary operations in track laying, some of the work can be done before starting to lay track. Peddling material, fiddling and lining ties may be done beforehand. Spiking can be partially done while setting up the steel and back bolting can be done after the steel is set up and spiked to gage. Track should be jointed up and gaged when laying, in order to obtain correct expansion. If rails are set up and the angle bars not put on, it is impossible to keep some of the expansion shims from falling out, and the ends of rails are liable to run past and necessitate shifting a number of them, when jointing up later.

"*The foreman* is responsible for both the quantity and quality of work done. He must organize the gang, and must be ready at any time to make changes necessary on account of the absence of laborers. If a number of men leave at the same time and new men are not available, the whole gang must be reorganized. As the assistant foreman's time is constantly taken up by the rail gang, the foreman must supervise the spiking and back bolting as well as inspect the work of the assistant foreman."

Cost of machine tracklaying and organization of gang on Erie R. R. in 1910.

The following data on tracklaying by machine are given by Mr. C. K. Conrad, Assistant Engineer for the work in the low-grade freight line from Guymard to Highland Mills of the Erie R. R., in the Railway Age-Gazette for June 3, 1910. A Hurley tracklaying machine was used.

After many trials with fewer men, it was found

that the best results were obtained with 51 men, working as follows:

1	General foreman.
1	Foreman.
1	Lineman stretching a light rope at proper offset distance from center line.
2	Tie spacers.
1	Tie marker, placing marks on ties so that center of tie will be set midway between rails.
1	Clamp man, applying hoisting clamp to rails before lowering.
1	Clamp man on ground disengaging hoisting clamp and steadying rail.
8	Spikers, four to each rail.
4	Nippers, two to each rail.
2	Bolters, one to each rail.
1	Clamper, holding angle bars for bolts.
2	Barmen, holding rail to gage.
1	Spike peddler.
26	Total in front of wheels of machine.
1	Engineer, in charge of the machine.
1	Assistant, working rail conveyor, as rails leave the friction rolls.
1	Bolter, removing bolts as rails leave the roll.
1	Fireman.
1	Watchman (night).
2	Feeding ties to dogs at rear of machine.
7	Total on machine.
2	Breaking out ties.
8	Spacing ties.
1	Watching and guiding ties.
11	Total attending to the ties.
1	At rear hoist.
1	Advancing rails on rollers.
2	Placing angle bars, and one bolt on front end of rail.
2	Bolting to forward rails.
1	Tightening bolts.
7	Total feeding the rail.

Cost of laying track. Nearly all of the second track on the Erie & Jersey was laid by hand. As most railway companies are familiar with this cost on their own line, it seems advantageous to compare it with the cost of the first track in order to give a correct idea of what the cost with the machine would be under the same conditions.

With a machine laying a mile per day the cost was as follows:

Laying track by machine

1 General foreman at $5.00		$ 5.00
1 Engineer at $5.00		5.00
1 Fireman at $2.25		2.25
1 Foreman at $3.50		3.50
50 Laborers at $1.50		75.00
1 Watchman (night), at $2.25		2.25
Machine, coal and oil		30.00
Full bolting and spiking after passage of machine:		
1 General foreman at $5.00		$ 5.00
1 Foreman at $3.50		3.50
50 Laborers at $1.50		75.00
Loading materials—ties:		
1 Foreman at $3.00		$ 3.00
35 Laborers at $1.50		52.50
Engine and crew		35.00
Rails and fastenings:		
1 Foreman at $2.00	$ 2.00	
20 Laborers at $1.50	30.00	
Total	$ 32.00	
6,963 lin. ft. of rail and fastenings loaded:		
This gives per mile of track	$ 48.53	
Engine and crew	35.00	
Total rail and fastenings		$ 83.53
Total per mile of track		$380.53

Laying second track by hand

Spacing ties, spiking and full bolting 3,000 ft.:

2 Foremen at $3.00	$ 6.00	
74 Laborers at $1.50	$111.00	
Total	$117.00	
Per mile		$205.92

Loading ties:

1 Foreman at $3.00	$ 3.00		
74 Laborers at $1.50	52.50		
		$55.50	

Unloading ties:

1 Foreman at $3.00	$ 3.00		
6 Laborers at $1.50	9.00		
		$12.00	
Engine and crew		35.00	
			$102.50
Loading rail and fastenings, same as for machine			$ 48.53

Unloading rail and fastenings:

2 Foremen at $2.00	$ 4.00	
28 Laborers at $1.50	42.00	
Total	$ 46.00	
Above worked four hours	18.40	18.40
Total per mile of track		$375.35

It should be realized, of course, that these figures do not represent the cost of continuing the work day by day; but they are representative figures for each class of work under similar conditions. The cost of laying the first track of a double track railway by hand is variable, depending largely on the accessibility of the roadbed for teams, as the ties are usually transferred from the tie car to the front by this means. The second track should be laid at a fairly regular cost.

So far as the track laid by machine is concerned, it is not possible at this date to determine which track was so laid. When laying down grade there is a tend-

ency to open the joints. Clips for the proper temperature expansion are a necessity. From the experience with the machine the following may be accepted: (1) On a new line 25 miles long, or more, the machine will prove economical. (2) The track laid with the machine will be as satisfactory as track laid by hand. (3) The organization will be reduced in number by 150 to 200 men. (4) It is feasible to lay one mile of track per day up to a limit of 12 or 15 miles from the supply base. (5) The danger of injury to men is largely reduced.

II

SPIKING AND GAGING

No. of spikes per mile of single track.

Size Meas'd Under Head	Av. No. per Keg of 200 lbs.	KEGS PER MILE. (4 Spikes to a Tie) Using 33 ft. Rails, 20 Ties per Rail	Using 33 ft. Rails, 18 Ties per Rail	Using 33 ft. Rails, 16 Ties per Rail	Using 30 ft. Rails, 18 Ties per Rail	Using 30 ft. Rails, 16 Ties per Rail	Using 30 ft. Rails, 14 Ties per Rail	Ties 2 ft. C to C
6 x 5/8	260	49.2	44.3	39.4	48.7	43.3	37.9	40.6
6 x 9/16	350	36.6	32.9	29.3	36.2	32.2	28.2	30.2
5½ x 5/8	290	44.1	39.7	35.3	43.7	38.8	34.0	36.4
5½ x 9/16	375	34.1	30.7	27.3	33.8	30.0	26.3	28.2
5 x 9/16	400	32.0	28.8	25.6	31.7	28.2	24.6	26.4
5 x ½	450	28.5	25.6	22.8	28.2	25.0	21.9	23.5
4½ x ½	530	24.2	21.8	19.3	23.9	21.3	18.6	19.9
4½ x 7/16	680	18.8	17.0	15.1	18.6	16.6	14.5	15.5
Spikes per mile		12800	11520	10240	12672	11264	9856	10560

In ordering spikes allow for extras, waste, etc.

No allowance made in this table for broken or lost spikes.

Hints about spiking. Track should always be kept full spiked and in perfect gage. In order to keep it thus, a gage of the standard width should be used, and when track is spiked the gage should be squared across, about six or eight inches ahead of the tie, and remain between the rails until the tie is spiked. The outside spike should not be allowed to draw the rail too tight on the gage or to be driven loosely, which would affect the width of the track after the gage is lifted. When gage is tight, start inside spike first; when loose, start the outside spike first. Bad gaging detracts from the appearance of an otherwise good

track and makes the track more likely to be kicked out of line. To be driven properly a spike should rest upon its point almost vertically when receiving the first stroke, which, if delivered properly, will leave the spike perfectly straight up and down which is the way it should be continued. Care should be taken never to strike the last blow on a spike too hard, as this may crack the head or break it off, rendering the spike useless.

To draw a spike in frosty weather, or to draw a spike out of an oak tie at any time of the year, tap the spike on the head with a spike maul once or twice before attempting to pull it out of the tie with the claw bar. In most cases there will then be no difficulty in pulling the spike without breaking it. Tapping the spike with the maul loosens its hold on the wood of the tie and makes it easier to remove. If an opposite course be pursued and trackmen try to pull spikes without doing as above directed, a great number of them will break off under the head.

Where to drive spikes. The spikes should be driven about two and one-half inches from the edge of a track tie. Both inside spikes should be driven on one edge of a tie and both outside ones on the other edge in order to prevent the tie slewing and also to assist in holding the rail from creeping. The spikes take a better hold in the wood of a tie, and support the tie under the rail better when driven in this way. An oak tie will split open on the ends in frosty weather if the spikes are driven in the center of the tie, which will cause it to decay more quickly and necessitate its removal from the track before the tie which remains whole. Another reason why the track spikes should be driven in the sides of the ties is that the timber in the center of most ties is softer, while as a rule the sides of the ties are sound.

The diagram, Fig. 5, shows the correct and incorrect methods employed in regard to the location of the spikes on the outside and inside of the rail. An examination of these sketches will bring this subject to the proper view point more easily than a great amount of explanation would, if it be borne in mind that the end of the tie on the outside of the curve is the one that is shoved ahead more than the end on

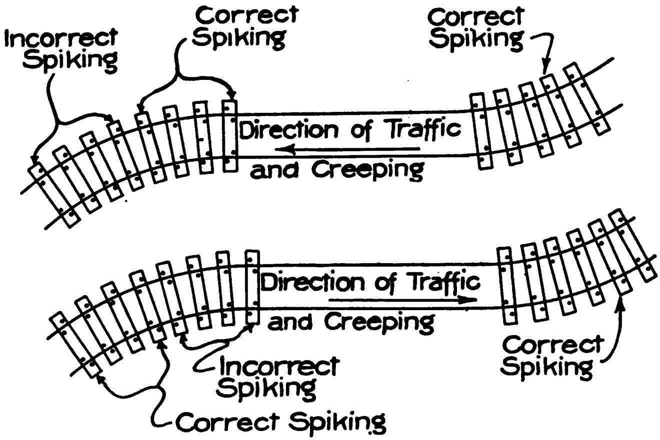


Fig. 5. Correct and Incorrect Methods of Placing Spikes

the inside, which is due to the tendency of the outside rail to creep more (doubtless on account of the sliding of wheels because of those on the outside making the greater distance). The rule which should be followed for selecting the best location for spikes to counteract the creeping and transfer the strain to the ballast through the medium of the ties, which is the way the strain must eventually be resisted, is as follows:—

On double track the inside spikes should be placed

at the receiving side of the tie and the outside spikes at the leaving side. On single track the outside spikes should be placed at the side of the tie in the direction of creeping and the inside spikes at the other side.

Screw spikes. The following notes appeared in the Railway Age Gazette:

"The first installation of screw spikes of any magnitude was one of a half mile on the Santa Fe near Topeka, Kan., in 1908. Since that time the mileage has risen over 200 miles annually. The Santa Fe has over 150 miles of screw spike track and is now (1915) placing them in eight ties per rail on the western lines when laying new 90-lb. rail to secure a more rigid track construction. The Lackawanna is the largest user of screw spikes, having employed them exclusively in main tracks for both renewal and construction work for the past four years, until it now (1915) has over 12,000,000 in service. This line is one of relatively heavy grades and curvature with an average density of traffic of about 4,000,000 ton miles and 600,000 passenger miles per mile of line for the system, which figures are trebled if the main line only is considered, so that the service is unusually severe.

"Wherever introduced, the screw spike has encountered the opposition of the track men, who have pointed out numerous objections. The one most emphasized has been the difficulty of removing the spikes when necessary to replace rails following derailments or during relaying operations. The Lackawanna has a dense freight traffic on heavy grades, and therefore has its share of derailments. It has been the experience of this road that by providing a stronger track the screw spikes have materially decreased its destruction as well as the delay to traffic while it was being repaired. Another threatened disadvantage that has not been encountered in the experience of the Lackawanna is difficulty in keeping

the screw spikes tight. To offset these real or fancied disadvantages, screw spike track construction gives a stronger track, requires less maintenance after installation and greatly retards the destruction of the ties.

"To secure the greatest advantages from the use of screw spikes in the conservation of ties corresponding standards must be adopted throughout the track construction. It is obvious that it is not economical to use screw spikes with untreated soft wood ties or without adequate tie plates. While not so obvious at first glance, it is also important that the ties be properly adzed and bored before treatment to retard destruction uniformly. It is interesting to note in this connection that the use of screw spikes has enabled the Lackawanna to secure sufficient resistance against track spreading by using a flat bottom tie plate and thus decreasing the abrasion of the tie.

"Where traffic is heavy and the expenditures for maintenance are correspondingly high, the savings resulting from the adoption of a more permanent form of track construction are of course greater than on lines of lighter traffic where a relatively long life is secured from the track materials. On the other hand, the Santa Fe is using screw spikes on its western lines where the rainfall is small and the resistance of timber to decay is relatively great, and where the ties customarily fail from mechanical wear."

Comparative cost of cut and screw spiking are given by Mr. J. W. Kendrick v. p., A. T. & S. Fe R. R. in Ry. Eng. & M. of W.

He states that the cost of driving screw spikes is based on work done under unfavorable conditions on the Illinois Div. in 1909, and says that under ordinary conditions there should be little difference in cost of the two kinds of spikes.

A proper machine at the treating plant will bore

and plug 600 ties, with 8 plugs each, per day of 10 hours, at a cost of 3½¢ per tie. The cost of making the plugs will be about 1½¢ each. The cost of screw spikes will be 2.7¢ each; of tie plates 21¢ each. The cost of cut spikes will be 1.06¢ each. Assuming 3,000 ties per mile of track, with 4 spikes per tie, assuming that the same types of tie plates are used both with screw and cut spikes, and that 8 wooden dowels are provided for the plates with screw spikes, and no dowels are provided for cut spikes, the relative cost per mile of track would be as follows:

One mile of track with screw spikes and dowels.

12,000 spikes at 2.7¢ each	$ 324.00
6,000 tie plates at 21¢ each	1,260.00
Boring ties for, and driving, 24,000 dowels at 1¢ each	240.00
24,000 wooden dowels at 1½¢ each	360.00
Driving screw spikes (per mile)	150.00
Total	$2,334.00

One mile with cut spikes.

12,000 spikes, at 1.06¢	$ 127.20
6,000 tie plates at 21¢ each	1,260.00
Driving cut spikes (per mile)	150.00
Total	$1,537.20

Experience in the use of screw spikes. The following notes give a comprehensive outline of the experience up to that time on American railroads.

"The general use of screw spikes in both new construction and maintenance on the D. L. & W. R. R. was started at the beginning of 1910, and during the past five seasons there have been placed in new tracks and in maintenance of old tracks 5,120,000 flat-bottom tie plates and approximately 12,272,000 screw spikes.

"As would be expected some mistakes were at first made, and no doubt later developments will change

some of the present practice. As a whole, however, the screw spike installation has proven very satisfactory, and no conditions have developed such as to cause any doubt about the ultimate success of the undertaking. Many minor difficulties which had been anticipated have not developed. It was fully expected that no small amount of trouble would be experienced from derailments, changing out broken rails, difficulty in gaging track on sharp curves, etc. It is a pleasure to state that, to the writer's knowledge, we have never had a derailment where the screw spikes have not been very much less damaged than the cut spikes in the same locality, and very seldom has a derailment broken off any screw spikes or damaged them to such an extent that they did not continue to firmly hold the rail in place. There have been many cases of derailment where it was not necessary to remove a screw spike, whereas nearly every cut spike on the damaged side of the rail was destroyed. Again, there have been some derailments where it is reasonably certain that bad accidents were prevented by screw spikes in some of the ties holding the rails in position, whereas the cut spikes in the other ties were destroyed. As to relaying rails, or removing broken rails, it is to be expected that the use of screw spikes will require more time to do the work.

"**Ties in use.** The Lackawanna Railroad first commenced to creosote cross-ties on an extensive scale in 1910. During 1910 and since that time all main and sidetrack renewals have been made with creosoted ties, excepting such chestnut ties as were available. These chestnut ties were used in sidetracks and on branch lines, where the service is light.

"From 1905 to 1909 a good many bridge-tie renewals were made with longleaf yellow pine, treated with 12 lbs. of creosote oil per cubic foot. These ties were

steamed at a 25-lb. pressure for an average of eight hours before treatment. 'Wolhaupter' flange tie plates (6 x 8½ x ⅜-in.) were placed on all the bridge ties, with the idea of protecting them. The dimensions of the ties varied with the bridge structure and were from 8 x 8 ins. to 10 x 10 ins. and 8 x 16 ins.

"On the main-line bridges none of the treated bridge ties have lasted to exceed eight years. Many of them were renewed in six and seven years. In no case was the timber decayed, but the failure was due to the shattering of the wood fibers under the rail seat and tie plates. As stated above, these were all longleaf yellow pine ties, with a very small percentage of sap. This failure has been attributed (1) to the fiber being injured by the steaming process before treatment; and (2) to the destructive action of the flanges on the tie plates. A total of 535 of these ties (8 x 12 ins.) were placed on the eastbound track of a deck plate girder bridge on the Buffalo Division in 1906, and had to be renewed in 1914. Untreated ties of the same size, and purchased under same specifications, were placed on westbound track of the same bridge in 1905 and are still in service and in fairly good condition. The old flange tie plates were removed from the deck of both tracks in 1910 and replaced with flat-bottom plates and screw spikes.

"For several years past there have been placed very few chestnut ties in main-line tracks. It was found that they did not last to exceed five or six years, on account of rail and tie plates cutting through them very rapidly. These same ties give excellent service and last many years in yard tracks or on branch lines where the traffic is light.

"As far as possible, hardwood ties are used on curved track. Longleaf yellow pine ties are generally used throughout on straight track. They are not used because they are preferable to hard woods, but on ac-

count of the difficulty in getting a sufficient supply of hard woods. A considerable number of loblolly and wide-ringed shortleaf pine ties were treated and placed in various services. However, unless otherwise stated, sap longleaf pine ties are referred to where pine ties are mentioned throughout this report. A good many gum, beech and maple ties were treated and placed in 1910. These ties were used in many sharp curves and their present condition will appear later on.

"**Tie plates.** For several years it was the practice to use flanged tie plates. It was found, after some years' experience, that much damage was done to the ties by the use of flange plates. It was, therefore, concluded that their use should not be further considered, either in connection with treated or untreated timber.

"A good flange plate, or something equivalent thereto in actual holding-power, is absolutely necessary to hold gage on many of the sharp curves. After a careful investigation of all available data on screw spikes, it was concluded to adopt them as a means of holding track to gage, and thus permit the use of a flat-bottom tie plate which would not destroy the fibers of the tie. Hence, since the spring of 1910, screw spikes and flat-bottom plates have been used generally in all ties placed in main tracks, heavy-running yard tracks and leads, but not in light yard tracks. In no case have screw spikes been used without tie plates.

"It is necessary to have a tie plate of sufficient size to provide a safe bearing area for the weakest kind of wood used. As the main-track ties are 7 x 9 ins. x 8 ft. 6 ins., it was considered not advisable to make the tie plates wider than 7 ins.

"The first tie plates which were rolled for our screw-spike construction were 7 x 10¼ ins. x ½ in.,

with raised lugs to support the heads of two screw spikes and with an intermediate shoulder on the outside of the rail. The plates were smooth on the bottom, and did not have a shoulder or raised lug for the screw-spike head on the inside of the rail. The following season the plates were lengthened to 10⅝ ins. and made ⅝ in. thick, with lugs for the inside screw spikes. Two holes were also punched for lag screws, one at either end. About a year ago they were again increased to ¾ in. in thickness.

Screw spikes. The first change from the standard cut spike fastening occurred in February, 1909. The heads of the screw spikes have been somewhat in-

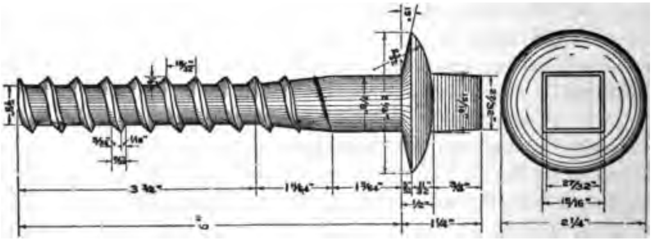


Fig. 6. Standard Screw Spike on D. L. & W. R. R.

creased from those first used, on account of the great deterioration from rust caused by brine dripping at certain points on the line. The standard screw spike now in use is shown in Fig. 6.

Holes for screw spikes. The first year that screw spikes were used an "Ajax" hand machine was used for boring all ties in the field, a template being used to spot the holes. Creosote oil was poured into all the holes as soon as bored. In 1911 a boring and adzing machine, manufactured by Greenlee Brothers, of Rockford, Ill., was installed at the creosoting plant. This machine operated more or less successfully, but was not of sufficient capacity nor heavy enough in

construction to successfully handle heavy hardwood ties. Accordingly, two new and larger machines, manufactured by the same company, were installed the fore part of 1913. These two machines have operated successfully, and have, without difficulty, adzed and bored 5,000 ties per day.

"During the year 1914, 523,935 ties were adzed and bored, the following data applying to this work:

Highest number of ties adzed and bored in one day by one machine	3,324
Average number of ties per day per machine while operating	3,011
Average number of holes bored per bit per sharpening	1,500
Average number of holes bored per bit	11,000

"It would not be safe to figure over 2,500 ties per day per machine, or 62,500 ties per month, working single shift.

"Eight men are required to operate one machine. In addition to these it is necessary to have a foreman, who is also a machinist, to keep the machines in repair and keep the knives and bits sharpened and ready to put on the machine when required.

"The cost per tie for adzing and boring, including the interest on the investment, depreciation, operation, running repairs, electrical current for operating the machines and trams, while the latter are taking ties to and from the machine, does not exceed 1½ ct. per tie.

"The ties are carried to the machine on trams, which are dumped mechanically. The machine is fed by a conveyor. Two laborers place the ties on the conveyors. Two surfaces are adzed at the rail seat, exactly in the same plane, regardless of the shape of the tie. The depth of cut can be regulated as desired for perfect ties. The depth required to get all ties adzed perfectly for the full length of tie plates depends upon the irregularity of the ties. After

passing the adzing heads, the tie is centered at each adzed surface by an overhead device to insure that the boring is done in the center of the adzed surfaces. The ties then pass by conveyor to trams and are ready for treatment.

"These machines are automatic, and it is, therefore, imperative that all parts continue to work properly while the machines are running. Trouble with any one part puts the entire machine out of commission.

"**Cost data.** The following data are a summation of the labor cost in connection with construction by the Lackawanna Railroad in New Jersey.

"These figures cover the entire line, amounting to approximately 60 miles of main track:

Cost of boring by hand in the field, 2,880 ties at $0.035	$ 100.80
Cost of applying 11,520 screw spikes at $0.019	218.88
Cost of laying track, less boring and placing of screw spikes at $0.085 per foot	448.80
Cost of surfacing 5,280 ft. track at $0.17 per foot	897.60
Average cost of labor per mile of main track	$1,666.08

"The above figures include the entire labor cost for putting the track in finished condition, but do not include any labor cost for the distribution of materials. It will also be noted that the cost of boring ties in the field on the above work amounted to 3½ cts. per tie, whereas the boring and adzing of ties, which is now done before treatment, has not cost to exceed 1½ ct. per tie.

"**Conclusions.** Ties. (1) Treated beech, birch, gum, hard maple, elm and probably other similar woods may be safely used with oak on sharp curves where the traffic is especially heavy.

"(2) From an economic standpoint, softwood ties, such as loblolly pine, should not be used on tracks of

excessive traffic, nor is it advisable to use them on sharp curves with moderately heavy traffic. An expensive fastening device, such as an extra large and heavy tie plate or chair, securely fastened to the tie by fastenings independent of the spikes securing the rail, with sufficient room for rail movement on the tie plate, thus reducing the movement between plate and tie to a minimum, would probably make it practicable to use softwood ties on straight track and light curves with moderately heavy traffic. It is not believed, however, that loblolly pine, or similar ties, can be economically used with good results on heavy curves, regardless of the style of fastenings.

"(3) As a rule, with woods which it will pay to treat, the poorer the quality of the timber the more elaborate and expensive the fastening must be if the mechanical life of the tie is made to approach the life of the treated timber.

"(4) The hardest track to maintain, from a tie standpoint, is on sharp curves, elevated for high-speed trains, where the speed of freight trains is restricted on account of grade conditions. Where traffic is especially heavy, such curves should be provided with the best of hardwood ties.

"**Tie Plates.** (1) Tie plates should be used on all ties where screw spikes are used.

"(2) The tie plates should project well beyond the base of the rail on the outside and less on the inside to counteract the tendency of rail to roll out.

"(3) As a rule, the required thickness of the tie plates will depend upon their projection beyond the base of the rail, and the traffic.

"(4) Four holes should be provided for screw spikes, so that two extra holes will be available if needed.

"(5) All holes should be punched from the top down and be as neat a fit for screw spikes as con-

sistent, so as to make all screw spikes act together in resisting lateral pressure. The outside screw spikes should be so protected by the shoulder on the plate as to prevent the rail base from cutting into the screw spike neck; otherwise, in case of derailment and slewed ties, it will be found impossible to remove the spikes without first straightening the ties.

"(6) A raised lug, or shoulder, both inside and outside of the rail base, should be provided to give support to the screw spike heads. This should assist in holding gage and materially reduces the breakage of spikes and damage to track in case of derailment.

"**Spikes.** (1) The size of screw spikes and the design of the thread should be carefully considered before a screw spike is adopted. Thereafter no changes should be made; otherwise the new screw spikes cannot be used in old holes without damaging the wood fiber.

"(2) Where salt brine drippings are excessive, screw-spike heads must be made sufficiently large; otherwise there may be difficulty in the future in removing the screw spikes from the track, due to corrosion. During nearly five years' service no screw spikes have been found that were rusted within the tie, and there was no rust to speak of below the head, although some spike heads were rusted so badly that they could not be removed with the standard tool.

"(3) The screw spike head should have tapering sides to prevent turning in the wrench socket after the size of the head has been diminished by rust.

"(4) Any mechanical device for setting down screw spikes must automatically release when the screw spike is seated; otherwise the screw spike is apt to be damaged in case of hardwood or the wood fibers destroyed in case of softwood.

"(5) Very little trouble is experienced by screw spike heads breaking off, either on account of track movement or derailed equipment. The heads are, at times, damaged to considerable extent by derailments, but as a rule the spikes are not broken, nor is their holding-power affected. Where screw spikes are broken off, a device for extracting the broken portion from the old hole without injury to the wood threads would be a valuable appliance.

"(6) When screw spikes are fully seated, no further strain should be put on them, as this will tend to destroy the threads in the wood or injure the spikes.

"**Holes for screw spikes.** (1) All ties should be bored at the treating plant before treatment. This can be done while the ties are being adzed, and not only insures that the holes are bored sufficiently deep, but provides for good treatment of all wood adjacent to the spike holes.

"(2) Where the ties are bored before treatment, the track must be to proper gage before the ties can be placed.

"(3) The holes for screw spikes should be of proper dimensions for the class of wood used, with due regard to the size of screw spike used.

"(4) A limited number of holes can be bored with one bit, after which its size will diminish so as to make it unfit for a hole of given size.

"(5) Holes should be bored somewhat deeper than the length of the screw spike. There is no serious objection to boring the holes clear through the ties.

"**Gage.** (1) With oak, birch, hard maple, gum or longleaf yellow pine ties, gage can be maintained with a flat-bottom plate, using two screw spikes on straight line and two or three on curves.

"(2) Heavy curves elevated for high speed, where heavy freight trains move at a slow rate of speed, are the hardest track to keep to gage.

"(3) Double spiking should be done on the inside of the rail.

"(4) Not only is the lateral and vertical resistance of a screw spike greater than that of a cut spike when both are first applied, but the lateral and vertical resistance of a loose screw spike is considerably greater than the lateral and vertical resistance of a loose cut spike.

"(5) When the threads in the tie are entirely destroyed, a screw lining (any one of several different varieties) may be used with good results.

"**General.** (1) All ties should be bored and adzed before treatment. This insures good gage, a perfect bearing for the tie plates and good treatment under the rail seat and around the screw spike holes.

"(2) In placing screw spikes, they should be driven by hammer only sufficient to make the threads take hold. If rigid instructions are not carried out, laborers will continually over-drive spikes, and thus destroy the wood fibers near the top of the holes.

"(3) Screw spikes with flat-bottom plates on hardwood ties will hold track to gage on sharp curves under heavy traffic. The holding power of screw spikes in hardwood ties, after more than four years' service, is not materially reduced.

"(4) No screw spikes have ever been found so loose that they could be easily pulled out of the holes, and but few have been discovered which could be as easily extracted as a newly-driven cut spike. In no case, except with loblolly pine ties, have the threads in the wood been found weakened.

"(5) Screwspikes in maintenance work can be most economically used where all rail is of a standard pattern, so that regaging of track is not necessary in relaying rail.

"(6) Slight irregularities of track when frozen are liable to throw an excessive strain on screw spikes

where there are but a few mixed with cut spikes.

"(7) The best results with the screw spikes can be expected in new construction, and where the screw spikes in tie renewals predominate over cut spikes.

"(8) In relaying rail, cut spikes should never be driven in old screw spike holes, if the holes are to be again used for screw spikes.

"(9) No effort should be made to draw up a low tie with screw spikes when the roadbed and ballast are frozen solidly.

"(10) Screw spikes do not have to be continually set down, as do cut spikes, but should be gone over and set down properly after the plates are seated in the tie.

"(11) Flat-bottom plates with raised shoulders or lugs for the screw spike head make but little noise and do not rattle at all where ties are adzed before treatment.

"(12) It cannot be expected that the full life of all creosoted softwood ties, such as loblolly pine, will be realized without providing expensive fastenings from the start, and then it will probably be necessary to add some further device at a later late. Probably the most practical and least expensive device will prove to be one or the other of the lining devices to be placed in worn-out spike holes.

"(13) The use of screw spikes for the past five years has not made it necessary to increase the number of section men per mile of track.

"(14) Whether or not it will pay to use screw spikes will depend upon the cost of ties, their probable life and the amount of traffic."

The foregoing data were abstracted from a paper by G. J. Ray, Chief Engineer, Delaware, Lackawanna & Western R. R., in the Bulletin of the American Railway Engineering Association for March, 1915.

Gaging track. Section foremen should make an effort to gage all the track in their charge once a year. Early in the winter, and before general track work begins in the spring are the best times for this purpose, because then, on northern railroads, there is generally less of other work to be done than during the balance of the year, and it is best to utilize the period when track is frozen up to do gaging work and to apply tie plates.

To gage track out of a face, the tools required are:—

2 spike mauls,

2 claw bars for pulling spikes,

2 adzes for dressing a surface for the rail on the ties,

2 standard gages, one for gaging the track and one for testing the gage of track before pulling the spikes,

A good supply of track spikes and wood plugs to put in the old spike holes.

If there are any bad places on the section, begin gaging these first, but if the average is the same throughout, it is best to work from one end continuously.

When you arrive on the ground to commence work, take out all short kinks on the line side, and spike the rails to line, and have your men drive down all loose spikes on that side of the track before bringing the opposite side to gage.

The foremen should take one gage and test all the track ahead of the men and mark all ties where spikes have to be pulled. Keep only enough spikes pulled on the gage side of the track to make it handy to adjust rail to place ahead of the gage, and have the track always ready to close up for the trains to pass.

Have one of the men move the rails to place ahead of the gage with a lining bar, and do not try to draw it over with the spikes.

Do not spoil or waste any of the old spikes that are

fit to be used a second time, and if they arè oily or greasy throw a little dirt or sand on the head of the spike when you tack it into the tie; this will prevent the spike maul from slipping off the spike when driving it. Measure the gage and be sure that it is of the length four feet eight and one-half inches, and if it is an iron gage and the end lugs touch the joint fastenings, grind or file them off, tapering so that nothing but the rail will touch the gage when placed across the track.

If the gage on a section is not very bad, a foreman and two trackmen will do an average of one sixth of a mile per day, and with four trackmen a little more than double that amount of work. Gaging and spike-lining a section of track well during the winter, besides improving the track at that time, will enable the foreman to put a first-class line on the whole section during the following summer, and will materially lighten his other work.

Loose spikes. A section foreman should be particular to keep all spikes on his section driven down in the ties, and tight against the rails. Some foremen are not so careful in this respect as they should be; loose spikes in soft ties, especially where track is not level or on curves, leave the rail at the defective place liable to be turned over and cause an accident. You cannot keep track in good line with loose spikes, and in tamping loose ties when surfacing considerable time is lost holding up the ties. Care should be taken not to spring up the center of the rail, if of the lighter sections, and spoil the surface, thus making it necessary to go over the work a second time.

Respiking ties. Whenever it is necessary to pull the spikes out of ties in the track, changing rails or at other repair work, and you find that the old spike holes in the ties will do for spiking the second time without changing the gage of the track, do not use

a fresh place in the tie to drive the spike, but plug the old hole with a tie plug and drive the spike as it was before pulling. Ties soon rot and break off under the rail where spikes have been driven in different places, while the balance of the ties may be good, sound timber; this practice is termed "spike killing the ties" and is one that should be avoided. The increased use of tie plates of late years has obviated the necessity of gaging track so frequently on curves. Some roads use tie plates even on tangents to reduce the wear of the rail on the ties.

Creosoting ties. For the last several years most railroads have realized the importance of creosoting or treating timber with oil preservative against decay, since by so doing the life of the tie is greatly increased, and with the general adoption of tie plates, of which there is a great variety on the market, each style having its own particular merit, ties cut from soft timber can be used to advantage and substantial track maintained, a result that was not possible years ago before the perfection of the tie plate. The creosoting of ties at once suggests the use of tie plates on them to avoid the necessity of regaging and adzing any more of them than is absolutely necessary, since the penetration of the oil into the timber is somewhat limited, and if a tie is adzed after treatment the effectiveness of the preservative is destroyed or greatly impaired. One of the late practices to overcome this difficulty is to have the ties planed for the rail-bearings before treatment. When screw spikes are used and holes are bored for them, they should be filled with creosote oil and left until all of the oil is absorbed by the timber, which requires from four days to a week. For that reason it is best that this part of the work be done in advance of the time when the ties are to be applied. Men accustomed to the use of the template and boring can prepare the ties for

application at the places along the track where they happen to be distributed.

Boring ties by hand. Mr. C. W. Lane of the B. and O. Railroad has described the boring of 100,000 treated ties for use with screw spikes on a special form of tie plate, in the Railway Age Gazette, Nov. 20, 1914.

"The ties were bored at the road's treating plant at Green Spring, W. Va., the adzing being eliminated by using only sawn ties, and the work being done by small portable air motors capable of driving a 5/8-in. bit 6 in. into the wood.

"In the tie plant yard a standard gage track was paralleled by a narrow gage track 40 ft. away, and the sawn ties were loaded on flat cars in the yard, delivered at one end of a rude skidway built between the standard and narrow-gage tracks, bored on a rough platform at the narrow gage end of the skidway, and loaded on trams to be run into the cylinders for preservative treatment.

"The first skidway was in the form of a rude trestle work, sloping from a height of about 2½ ft. above the floor of a standard gage flat car to the level of the boring platform, which was at the height of the arms on the narrow gage tram cars. After completing this skidway its cost seemed too high and a cheaper method of building was sought. In building the next skidway a pile of ties that stood ready for treating was taken down to a level slightly below that of a flat car floor. Rails were then laid across this level crib-work of ties, and a boring platform erected at the narrow gage end at the level of arms on the narrow gage tram cars, as before. This was a cheaper form of construction than the other skidway; but for the final one three 67-lb. rails were used at the height of a flat car floor and the arms on the trams, the rails being supported by simple crib-work of ties. The

first or sloping skidway proved to be the most efficient, since thus the ties could be fed faster to men doing the boring.

"After picking up, loading on flat cars and delivering to the skidway the sawn ties, the places where the holes were to be bored were marked by using a template made of iron with holes exactly correspond-

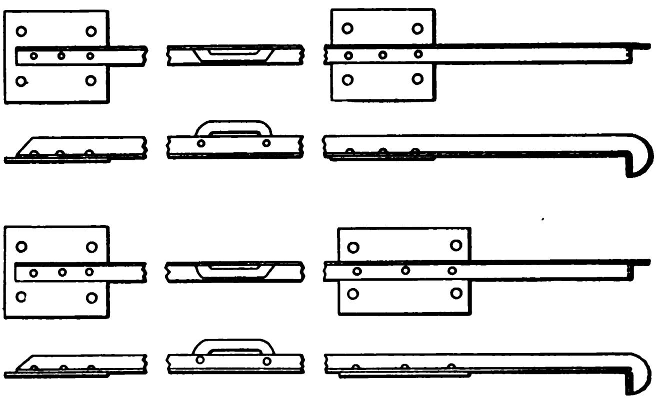


Fig. 7. The Template Used in Boring Ties for Tie Plates

ing to the holes in the tie plate that were to be used. Two of these templates, one for joint and one for intermediate ties, were constructed according to the accompanying sketch, Fig. 7.

"The joint ties required four holes bored for each tie plate, while the intermediate ties needed only two holes for each plate. The little hook on one end of the template was hooked over one end of the tie and thus determined the distance from the end at which the holes were to be bored; this was known as the 'line end' of the tie.

"Two men performed the operation of marking the ties for boring. The template was first properly

placed in position and then the men marked the places by driving a hand punch through the holes in the template with a wooden mallet. One little detail was quickly worked out which added greatly to the success of this part of the work. The punches were first made fast to a stiff spring which was in turn fastened to the template and which kept the punches out of the holes until struck. Instead of having to pick up and insert the marking punch in two or four holes and strike two or four blows with the mallet, according to the template used, one smart blow on the spring marked the whole set of holes. This little change naturally pleased the laborers and meant more output, which is only another way of saying 'more money for the men at a cheaper rate for the company.'

"The ties having been marked were pushed along the skidway to the men who did the boring. The little air motors driving the boring-bits were suspended from a sort of walking-beam or old fashioned well-sweep, pivoted overhead so that it could move up or down, or in a horizontal direction, as desired. As the motors were too heavy to handle steadily all day they were counterbalanced by weights placed on these walking-beams. The bits with which the boring was done were fitted with stops to insure the holes being bored to the exact depth desired, which in this case was 6 in.

"After the ties were bored they were immediately loaded on trams, stamped, checked, reported, and sent to the treating cylinders.

"In any statement of costs the particular conditions surrounding each bit of work bear directly on the unit-price, and the following prices are given as fairly well suited to the locality where this work was done, but with a full understanding that cheaper or possibly higher rates might fit the situation in other places. It cost 1½ cents per tie to sort out and load

ties in the yard and ½ cent per tie to deliver them properly piled on the skidway.

"A gang could bore 600 intermediate ties in 10 hours. The two men marking and pushing ties to the boring-platform and the two men doing the boring received 1½ cents per tie divided equally. These four men earned then about $2.25 per 10-hour day per man. The two men loading trams received ¾ cent per tie or $2.25 each for 600 ties. This made the total cost for an intermediate tie 4¼ cents.

"A gang could bore 400 joint ties in 10 hours. The rate for marking and boring these ties was 2¼ cents per tie, but the men loading the trams received the same rate of ¾ cent per tie because they could be loading other trams at regular yard rates during the time they had to wait for the slower moving joint ties to be bored. The total cost per joint tie was therefore 5 cents. A portion of these costs should not be included in the bill against adzing and boring by hand, because these same ties would, in the natural course of events, have to be picked up for treatment, which would cost something, varying at the different plants, say, approximately 1½ cents per tie."

III

GENERAL SPRING WORK

Overhauling track in spring. When the frost is leaving the ground in the spring, track foremen should remember to do all the little jobs which have been left over or neglected during the winter on account of frost and snow.

Clean up the station grounds and tracks, and pile up neatly all track or other material which may be scattered about the premises.

Gather up all trash, cinders, straw and other combustible material and waste it on the narrow banks or burn it up if more convenient. Particular care should be taken to see that there is no dry grass around any timber bridges; if there is, have it removed promptly by skimming it off with a shovel or covering with dirt and cinders. Water barrels at bridges should be examined and replaced with new ones if necessary to provide proper protection against damage to property from fire.

All switches and leads should be spiked to proper gage and line, and battered rails replaced by good ones; guard rails and frogs should be examined, and any defects in them remedied, or new ones ordered to replace them; but this is something that must conscientiously be done at all times regardless of weather conditions.

Right of way fences should be examined and repaired, especially in low places or where they cross watercourses. Loose planks in wagon crossings

should be taken up and cleaned underneath, and ragged or split ends should be dressed with adze, renewing as may be necessary, and then respiked to place.

The approaches to all highway crossings should be filled up and fixed, so that teams will have no trouble in crossing the track. All fence posts, crossing signs, whistling posts and telegraph poles, should be put in correct position and tamped solid.

Shimmed track should be watched and very thick shims should be replaced by thinner ones as fast as the heaving goes down, and all shims should be removed from the track as soon as it is possible to spike the rails to proper surface.

Soft spots in the roadbed will develop at this period of the year and must be carefully guarded against and repaired as fast as they develop. If impracticable to keep them in condition so that the regular speed of trains can be maintained, it is better to resort to the slow order than to permit any condition to go far enough to risk an accident.

Washouts. Section foremen should keep a sharp lookout for washouts at all points on their sections, since the time of the year is now at hand when thawing snow and rain combine to increase the quantity of water above the surface of the ground; and as the frost goes out of the ground but slowly at best there is always danger to a railroad from the accumulation of too much water at one place. This may damage the track by undermining or washing away the roadbed, or by loosening the earth on hillsides along the track, or it may cause quantities of earth, stones, or trees to fall or slide upon the track.

Ditches should be opened up and waterways cleared of all obstructions, and all track, trestles, bridges and culverts should be examined frequently, every day if necessary or, for that matter, as many times during

the day as good judgment would dictate. Where there is likely to be any trouble the section foreman should remain out with his men day and night, and do all in his power to keep the track safe, always remembering that upon the vigilance of himself and men may depend the lives of trainmen and passengers.

In case of storms where the foreman has reason to apprehend danger, and his section extends both ways from his headquarters, he should send a man over the short end of it with instructions to reach the section limit as soon as possible, and to remain there and use the necessary signals to flag trains should he find anything dangerous on the way out. The foreman should go as rapidly as possible in the opposite direction towards the other end of his section, leaving a man a sufficient distance ahead of the first break or washout to flag trains following, in case they should get over the other end of the section safely. The foreman should note the location and dimensions of all places needing repair, but he should not stop to do any work until the end of the section is reached, and the men have all been posted to remain and flag trains for all the dangerous places found.

The foreman should then go to the nearest telegraph office and make report, stating fully the condition of the track on his section, giving location and dimensions of all breaks in roadbed or track, bridge and culvert numbers, number of bents destroyed in bridges, and any other information that would be valuable as a basis from which to calculate the amount of material or force necessary to put the track in good condition.

This will insure the safety of trains, and enable the train dispatcher to hold them at convenient points until the track and bridges are repaired.

After reporting the condition of his section the

foreman can go to work repairing small breaks at points where a large gang of men could not work to advantage, but the men who are flagging at dangerous places should not be called away until relieved by extra forces sent to protect and repair damage.

Instances have occurred where foremen have stopped to repair the first bad spot found, and allowed trains to run into other bad places on their sections. It is always the foreman's duty first to protect those dependent upon him for safety, and then to notify superior officers of the condition of his section. If all of the track on the section is safe, send a report to that effect so that trains will not be delayed.

Repairing track. When track that has become rough or uneven is being repaired, all low places should be brought up to surface. Both rails on straight track should be level, and on curves the elevation should suit the degree of the curve.

Lining old track. The track should be kept in perfect line at all times. Nothing contributes more to the smooth riding of a train than a true line of rails. The foreman, when lining track, should do as much as possible with his back to the sun, because in that way he gets the best view of the rails. It is also necessary to look at the track line from the opposite direction, especially when lining across a sag, and also at ends of curves. A common fault in lining the last four or five rails on tangents is to throw the track too far out. Very few trackmen can line track perfectly by going over it once unless they are experts and have perfect sight. Always stand as far away from the place to be lined as your sight will allow, and train your men to line by the motion of your hands when first putting the rails in place. By standing too close to the place to be lined, you are likely to throw a swing to one side of the track. This is a

common fault with many foremen. If you have a section which the previous foreman left in bad line, show your ability by remedying its defects in that particular every time you have an opportunity. If a foreman has some track on his section which has settled down and is out of line, where the ground is wet or soft, and he has not the force of men necessary to move it in the usual way, the work of putting it to place can be done with a small gang by pulling the spikes out of two or three ties in a rail length at a time, and using the lining bars on top of the dead ties under the rails, thereby gaining a solid foundation to rest the bars upon and much more leverage than could be obtained with the bars in the ground. After the track has been lined to place, the dead ties can be shifted to their proper positions.

Some of the instructions herein given as to track lining may seem unimportant to those who know it all, but it should be remembered that there are "kinks" in all trades and as far as suggestions may be made which would be useful to any one engaged in this line of business, reference will be made to them as occasion may occur.

Tightening bolts. Some trackmen think that all bolts should be kept as tight as it is possible to make them. This is an error that any trackman may fall into until he is convinced to the contrary. There are several kinds of nut locks for track bolts in use on the railroads throughout the United States, the majority of which are devised for the purpose of locking the nut, and at the same time allowing the rails to contract or expand after the bolts are tightened without danger of breaking them. The section foreman, and his men sometimes tighten up all the bolts on a section, even if they can make only a quarter of a turn with the wrench; in fact, many foremen add pieces to the ends of the track wrenches, so that the

men may be able to get more leverage, and as a result of their labor everything on a joint in the shape of a nut, lock, or washer, has every particle of spring or elasticity taken out of it, and the bolts are broken by the action of traffic or by the expansion and contraction of the rails due to changes in temperature. Thus what should ordinarily be serviceable material is rendered useless by such treatment. A joint with either four or six bolts, and with a spring nut lock on each bolt, should have the nuts tightened enough to get the full force of the resistance of the material used for a washer between the nut and the angle bar. A comfortable twist of the track wrench with the hand, after the nut is run up to place will be found sufficient force to use when tightening bolts. When bolts are tightened in this way and there are angle bars or patented joints slot-spiked to the ties, all danger of the bolts or rails being injured is avoided, and the rails can contract and expand without track creeping. To prevent trackmen from breaking bolts when tightening them, track wrenches should not be too long, and the use of pieces of pipe on the end to increase the leverage should be prohibited.

However, with the large sized bolts in use and with the design of heavy joint fastenings lately developed, the length of track wrench has been increased accordingly, and a standard of 36 in. is not unusual. It should not be understood from the above that all the trouble experienced is from keeping bolts too tight, for such is not the case, but the foreman should be impressed with the importance of giving this work proper attention. When, for instance, new rails and angle bars are installed, they are ordinarily covered with a light scale or rust, due to lying out in the weather for some time before being used, and even if the bolts are applied so that the joint is substantially tight at first the scale soon wears off by the action of

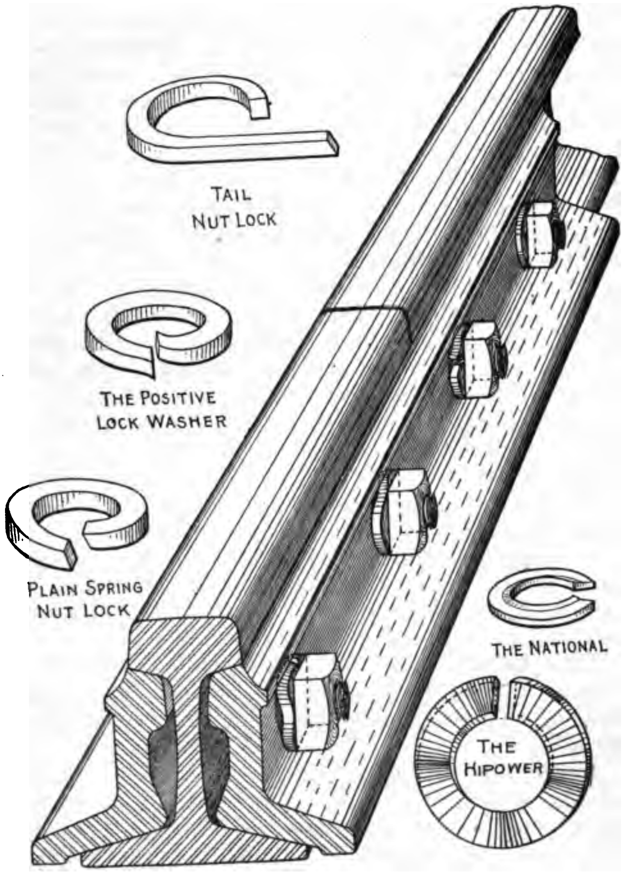


Fig. 8. Various Types of Nut Locks

traffic and it becomes necessary to go over and tighten the nuts to complete the seating of joints up to the rail. If for any reason this second tightening is neglected, the joints become loose and it is not a great while before the threads of the bolts become damaged on account of the play, with the result that the same bolts cannot be further tightened and must be removed and others applied. A great many bolts have been damaged in this way and money spent in purchasing others, where a little labor expended in the right direction would have avoided it all.

All sudden changes of temperature affect the bolts on account of the expansion or contraction of the rails. This is most noticeable in the spring and fall of the year. Foremen should not neglect to tighten up the bolts at any time when it is necessary. Always remember that loose bolts make low joints and increase the labor of track repair.

Nut locks. There are a number of good nut locks on the market today, each possessing particular merits, which permit of keeping the bolts tightened up with a minimum amount of labor, and prevent excessive wear of the joint fastenings. The nut locks illustrated in Fig. 8 are in very general use and are well adapted for rail joints.

Line on bridges. Section foremen should be particular to keep the rails on all bridges in good line, as well as to keep a good line and surface on the approaches.

Repairing bridges. All repair work on bridges should be done by bridge men or those in charge of such work. Section foremen should not attempt to do any work on bridges for which they have not the proper tools or the necessary practice. Any work that is necessary in an emergency should be done and a report of it made to the proper authority, as to anything further that may be considered necessary.

IV

DRAINAGE

Ditching. In order to ditch a cut properly, measurements should be taken from the rail to the bottom of the face of the cut at different places along it. Ascertain at what average distance from the track it will be best to have the back of the ditch. This is very important, because in the majority of cuts on a railroad the line of face is more or less irregular and not truly parallel to the track, and the best distance from the track for the back of a ditch is that which will give a good ditch without moving too great an amount of material. After a foreman has decided how wide the ditch should be, he should line it with the shovel or drive stakes along the back of it for his men to work by, otherwise they will be apt to make it crooked. Nothing is more unsightly than a crooked ditch, and it will fill up more rapidly than a straight one. The ditch should always be a little deeper at the lower end of the cut, and gradually grow shallower as it goes up grade. If you ditch parts of two or three cuts on your section at different times, each of the cuts will have some time to drain off, the material in the ditches will be dryer and in better condition to work, and men can thus do more than if kept in one very wet cut all the time. Always carry the discharge end of a ditch so far away from the track that there will be no danger of water from the ditch washing out the embankment under the track. A

time of the year should be selected when the weather is not favorable for other track work.

Form of ditches. The width of a cut and the slope of its face on each side of the track must always govern, to a certain extent, the distance from the track rails to the back of a ditch. All railroad cuts should be opened so wide when the track is first laid that there will be room to make all ditches a uniform distance from the rail. A ditch should be deep enough to thoroughly drain the track, and the distance from the rail to the back of it should be in proportion to the depth of the ditch, giving the water an easy fall from the track and free passage through the ditch, so that there will be no danger of its washing the shoulder of the grade, or undermining the track. Deep ditches close to the track in a cut sometimes weaken the foundation and wash away the ballast outside the ties, especially where the ballast is of sand or gravel. The bottom of a ditch should be from eight to ten feet from the rails, where the width of grade will allow it, and should be two feet below the bottoms of the ties.

Grade of ditches. If a cut is level throughout its length, the ditch will necessarily be deeper at the ends than at the middle. Where the grade of a cut descends toward the ends from the center the average depth of the ditch may be the same throughout the cut. Trackmen should always begin to ditch at the lower end of a wet cut, and finish up as they go. The piece ditched every day will help to drain off the water behind. The principle governing this is that a ditch must have a fall in the direction toward which the water is to drain.

Cleaning out ditches. Old ties or other obstructions should never be allowed to remain in the ditches along the track. They should be cleaned out thoroughly every fall and the last thing before winter

sets in, so that during the continuance of the spring rains, or while snow is melting, the water can pass off freely without injuring the track.

Protective ditches. A small ditch made with a plow along the top of the side of a deep cut, and near the edge of its face, will carry off the surface water and protect the side of the cut from washing into the track ditches and filling them up too rapidly.

If the track through a cut has a uniform grade advantage may be taken of it to turn any surface water flowing near the upper end down through the ditch and thus keep it scoured out. There is no danger of injury to the track if the amount of water flowing to the upper end of the cut is not too large.

A ditching template. A simple device like that shown in Fig. 9 is very handy to use when ditching.

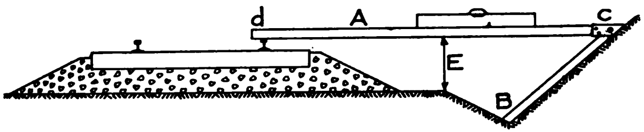


Fig. 9. Ditching Template

It can be made as follows: Use for the long piece A a straight edge 1 x 4 inches, 12 feet long. For the short cross-piece B use a piece of board 1 x 3 inches, four feet long. On one end of the long piece fix a piece of sheet iron, C, twelve or fourteen inches long, double it, and bolt the ends of it through the wood, leaving a space through which the short piece, B, can be passed freely. A hole should be bored through the sheet iron, so that a set screw or a bolt can be used to secure the short piece at any distance from either end of it. The cross piece, B, of the ditching rule should be set so that the back of it will be at the proper angle for the back of the ditch, and upon one side of it should be marked the distances by which to

regulate the depth of the ditch. When in operation, one end of this ditching rule, d, should rest upon the nearest track rail, and at the other end the material should be removed from the face of the cut, until the cross piece, B, rests in proper position to shape the ditch. Then, by trying the spirit level on top of the longer piece, and adjusting the cross piece to the required depth, the bottom level of the ditch can be carried uniformly throughout the length of the cut, if the track is in true surface, without any change in the rule. The template should be fitted to place at distances of a rail length or less, and the men will have a guide to work by, and can cut the ditch correctly without any additional labor. A marker can be put on the long piece, which will show where the ditch slope commences outside the ends of the track ties. If it be desirable to lower the ditch, say twelve inches in as many rail lengths, it is only necessary to let the cross piece, B, down one inch every thirty or thirty-three feet, at the same time keeping the long piece always level on the top. In like manner, by shortening up the cross piece the ditch bottom can be gradually raised or made more shallow. When constructing ditches in accordance with the standards prescribed by the various railroads, of course the figures as taken from such standards should be used in setting the template to shape the ditch. E represents the difference in elevation between top of rail and sub-grade.

Channels for conveying the water away from the track should be sufficiently large to perform the duty required of them during a freshet as well as when only an ordinary amount of water passes through. At all marshy or low places where water might remain standing alongside of the track enough openings should be made to insure a solid dry roadway. The embankment should also be rip-rapped along its sides

if there is any possibility of strong winds or rapid streams forcing the water against it and washing the material away.

Where musk rats are plentiful and cause damage to the track by burrowing under it, a heavy coating of cinders and slag along the sides of the embankment is a most effectual protection against their depredations. The cinders form an alkali in the water that tastes bad, besides which they are too sharp for the animals to burrow through, forming thus an admirable remedy against their ravages.

In deep, wet cuts where the material has a tendency to slide, the roadbed should be widened out much more than at any other point, and the face of the side of the cut should be made with a very gradual incline from the top of the cut to the ditch. If it will grow some grass, all the better.

The work of widening cuts and roadbeds can be done at less cost and to better advantage before the track is laid than afterwards.

The bottoms of ditches that run alongside the track through a cut should be carried not less than ten feet from the rails on each side, and as far below the bottoms of the track ties as it is possible to have them. They should retain a nicely proportioned incline from the end of the ties to the ditch. Open ditches or tiling which are too close to the track, or not deep enough below the track ties, are only a makeshift and a hindrance to maintaining a good, dry track. Coarse stone makes a good foundation in a wet cut, if laid beneath the ballast in which the ties are imbedded, but can be dispensed with where the track can be raised above the mud without spoiling the surface or grade standard. In fact, this latter is the most economical method (after a track has been laid) of draining a track and making a good ditch at the same time. Briefly stated, to drain the track in a

cut, the same conditions must exist, as nearly as possible, as where the track is laid in ballast on a good, solid fill or embankment, several feet above the surface of the ground.

The incline of the sides of the embankment should be a natural slope, with no abrupt angles. No earth embankment can be prevented from washing without artificial means where the incline is so steep that vegetation will not grow upon it.

Pipe culverts. Cast iron pipe from 12 in. to 48 in. in diameter provides a splendid means of passing the water from one side of the roadbed to the other. Concrete pipe is replacing this to some extent now.

Where the conditions are favorable stone or concrete arches should be installed with good, strong, side walls, a paved floor and wing walls at both sides of the embankment, to take the place, as far as possible, of all small wooden bridges.

Grading cuts. Wet, soft cuts on railroads are a great annoyance, and very expensive for the companies that are troubled with them. They often necessitate increasing the section force or organizing ditching gangs, and require extra quantities of ballast.

In the spring and summer the track in wet cuts is rough; in winter the track in bad cuts heaves up and requires considerable labor and expense to keep it safe, and owing to the frequent spiking and the nature of the material in which they are laid the ties soon decay and have to be renewed. In new railroad construction this can often be remedied by widening the roadbed in proportion to the depth of the cut, or in conformity with the nature of the material through which the cut is made instead of following out the ironclad rule which makes the width of the roadbed the same in all cuts. A practical and experienced man should have charge of the grading work on a

new road, with authority to widen the roadbed, or ease the side slopes of any cut, in a manner that will protect the track from the effects of heavy rains or a springy bottom.

Surface ditches should be put along the tops of all cuts to run off the water at the ends, and to prevent it coming in on the track over the faces of the cuts.

Drainage of high fills. Mr. Earl Stimson, Maintenance of Way Engineer on the B. & O. R. R., has described in Ry. Eng. & M. of W. the drainage of two fills which gave a good deal of trouble on account of settling, on the Baltimore Division of that road, known as the Orangeville Fill and the first fill east of Eldridge.

The description is as follows:

"Before the work of drainage was commenced, it was thought that the sub-grade had settled under the track, forming water pockets. The fills being of impervious clay, the water could not drain off, and gradually softened the material, causing the fills to settle slowly, the material working out at the base.

"However, when the drainage work was commenced it was found that this condition did not exist, as will be seen by the cross section which represents typical conditions in both places. The Orangeville fill is 4,400 feet long, but only 200 feet have given any trouble on account of slippage. At this point the fill is 25 feet high with the slip all on the westbound side. The eastbound track requires no more attention than other points with a fair sub-grade.

"The original ground surface is of good supporting material so that the settlement could not be attributed to a poor foundation. The first section cut in the fill was cut down to the original ground to develop any water pockets if they existed. This section was not, however, cut through the entire width of the fill, as the material under the eastbound track

was found dry and in good stable condition. From time to time, cinders have been unloaded at this point and used to bring the fill up to normal sub-grade elevation and fill out the shoulder. The first section cut showed the cinder extending to a depth of 12 feet below the top of rail. Underlying the cinder was a layer of slippery saturated clay, about a foot in thickness, upon which the cinder moved toward the toe

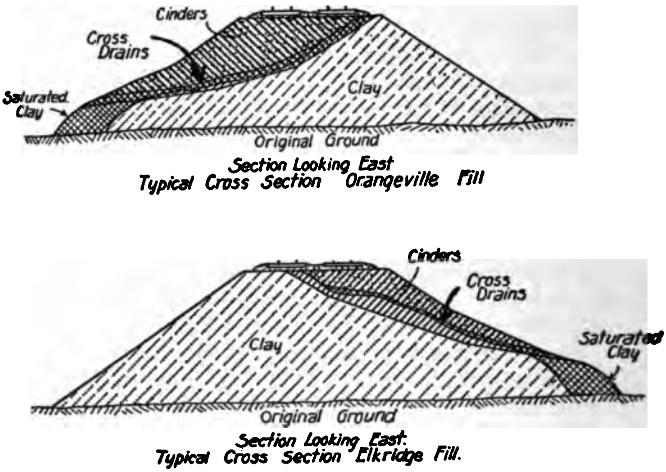


Fig. 10. Cross Sections of Two High Fills on the B. & O. R. R.

of the fill. Although it was not marked, there was evidently some movement of this clay which would account for the depth of the cinder under the track.

"It is probable that this condition is the result of water pockets. The pumping action of passing trains has worked the shoulder of the fill down also, leaving no defined pocket and forming the section

shown. Under the layer of saturated clay, the material rapidly became dryer and assumed normal conditions.

"Five cross drains were constructed at points where the settlement was most marked. The first section cut having developed the fact that there was no water pocket in the fill, the subsequent cross drains were cut only to a depth sufficient to reach solid material below the layer of saturated clay. No tile was used, the trenches being back filled with cinder.

"The fill east of Eldridge is 1,100 feet long with a maximum height of about 30 feet. In this case the settlement was on the eastbound track and for practically the entire length of the fill. Conditions were found to exist here as at Orangeville, except that there was more water, and as at Orangeville, no water pockets were found. Eighteen cross drains were constructed at intervals of about 50 feet. The excavating was cut through a wet material, and back filled with stone and cinder without tile. The cross sections illustrate the conditions as they existed and the cross drains as constructed.

"The cost of the work at Orangeville was:

Labor	$ 711.55
Material	357.37
Total	$1,068.92

"The unit cost of $213.75 per cross drain is high, owing to the amount spent on the first drain, which was in the nature of an exploration.

"The cost of the work at Eldridge was:

Labor	$ 486.52
Material	550.00
Total	$1,036.52

"The unit cost of $57.38 per drain is probably a better average on which to base future estimates for work of this character.

"During the progress of the work, the track was supported on twelve by twelve inch timbers, placed under the ties, the excavation being made four feet wide, closely sheeted and cross braced. No piling was used to support the tracks.

"When it was found that water pockets did not exist, it was thought that the cross drains would accomplish little, but contrary to expectations, the results obtained have been most satisfactory, the beneficial effects being noticeable almost immediately upon the completion of the work, and the stability of the fills increasing rapidly as they dried out.

"Results: A recent inspection has been made at Orangeville and Eldridge. The embankment for the last track built has slid down the slope of the original embankment so far that not much of the original material is left. The second track is now supported mostly by cinders. In time of dry weather this holds itself in fair equilibrium, but in wet weather the water running down the slope of the old embankment carries the new with it. The embankment seems to have thoroughly dried out at the point where the two ditches were dug to the bottom. After the first deep trenches were dug it was decided to dig only shallow ditches on the top of the embankment, digging them down as far as any moisture was found. These, of course, under the conditions, effectually drained the water which was standing upon the top of the old embankment, but did not help the track upon the new embankment.

"At the point where the deep excavations were made, the slip seems to have been cured, but where the shallow ones were dug, conditions are practically as bad as before. The ballast at the former point is

still in line and the track is standing up dry and solid, but in all other points it has settled badly and destroyed the line of the ballast leaving the one point where the deep excavation was made higher than the adjoining track.

"The conditions at these two points would indicate that the proper course to take to fully overcome the difficulties would be to dig deep excavations to the bottom of the fill and at intervals of about 50 feet throughout the entire length of the slip and fill with coarse rock and cinder."

V

SUMMER TRACK WORK

Renewal of ties. The month of May in northern climates is the season when the work of general track repair should be pushed steadily. Track is becoming dry and any track that has heaved during the winter is generally settled back to its old bed. The time for this varies with the location as to latitude and general climatic conditions. In the North Atlantic States the frost ordinarily leaves the ground in the latter part of March or early April and then the danger of track spreading is very great and should be carefully guarded against. If there are any poor ties in track they will show up at this time, and any weak spots that develop on this account should be attended to at once.

As soon as the worst parts of the section have been attended to in this regard, the foreman should go over and correct the line and general surface, which should engage his attention practically for the remainder of the month of April so that by the first of May he can begin at one end of his section the work of renewing those ties which are scheduled for renewal during the season. This work should be prosecuted continuously and should be interrupted only to correct line and surface as necessary. The tie renewals should have preference at this time, for then the ballast, if cinders or gravel, has not become hard or baked, as it will be in July and August. In addition to making better progress with the work on

account of this condition, the weather is usually pleasant, full efficiency can be secured from labor, and every tie put in at this time in ballast of whatever kind will have a good chance to become solid by the fall of the year. In other words, the track is now undergoing such repairs as may be necessary to put it in proper condition for the coming winter. The more those in charge of the work will consider the fact that winter is surely coming, the better the track will be.

Species of track ties. The species of wood in railroad ties are of great variety, ranging from cedar and other soft woods to lignum vitæ. The majority are, however, of cedar, cypress, hemlock, pine, chestnut and oak, and are used according to the character of the country through which the railroad runs.

Yellow pine ties are now secured in the South and brought in large numbers by rail and boat to help out the deficiency of other classes of timber in the states farther north. Cedar ties give a very long life in the track, as do chestnut, but if used without tie plates are cut very fast by the base of the rail. It is not uncommon to find chestnut ties in the track that have been there for sixteen years, and cedar ties that have given twenty years' service; however, cedar and other very soft wood ties cannot be trusted on curves without tie plates to resist the tendency of the rails to spread. White oak ties are the best and make the most substantial track, their average life being from twelve to fourteen years. Red oak ties last about four years on the ordinary railroad, but on street railways, where covered up and not exposed, they are quite suitable and give long service.

The usual size of ties for main track is seven inches thick, nine inches wide and eight feet six inches long (7″ x 9″ x 8′ 6″); for side tracks they are six inches thick, eight inches wide, and eight feet long (6″ x 8″

x 8′ 0″). The latter class are also adapted for use on all main tracks with light traffic and are often used with great success under heavy traffic. In size they vary according to the specifications of the particular company for which they are being cut.

Timber cross-ties can be divided into two classes, and these in turn can be subdivided as follows:

I. Hewn.

- (a) Quarter tie.
- (b) Slab tie.
- (c) Half tie.
- (d) Uneven tie.
- (e) Pole tie.

II. Sawn.

- (a) Quarter tie.
- (b) Slab tie.
- (c) Half tie.
- (d) Pole tie.

Fig. 11 shows, at upper part, (1): A quarter tie, from a tree quartered into 4 ties, having a little heart, which, if placed in track with heart up, will check quickly and if placed with heart down, as shown at (1-a), the heart is likely to be split away from the rest of the tie when the spikes are driven into it. (2): A slab tie, from a tree halved into two ties, and the same results occur as from quarter ties; both (1) and (2) when placed in the track, heart down, give sapwood as support for the rail, which will be quickly cut into. (3): A half tie, which requires considerable care in tamping or it will become canted. (4) An unevenly hewn tie with a narrow face on one side, which, if placed up, will very soon be cut into by the rail base, as shown at (4-a). (5) and (6): "Pole ties," so-called, which are the best for use in

the track, owing to the heart being at the center, with sapwood on the outer corners only. These, when placed in track, will give longer life and allow correct spiking for gage and to prevent creeping, and

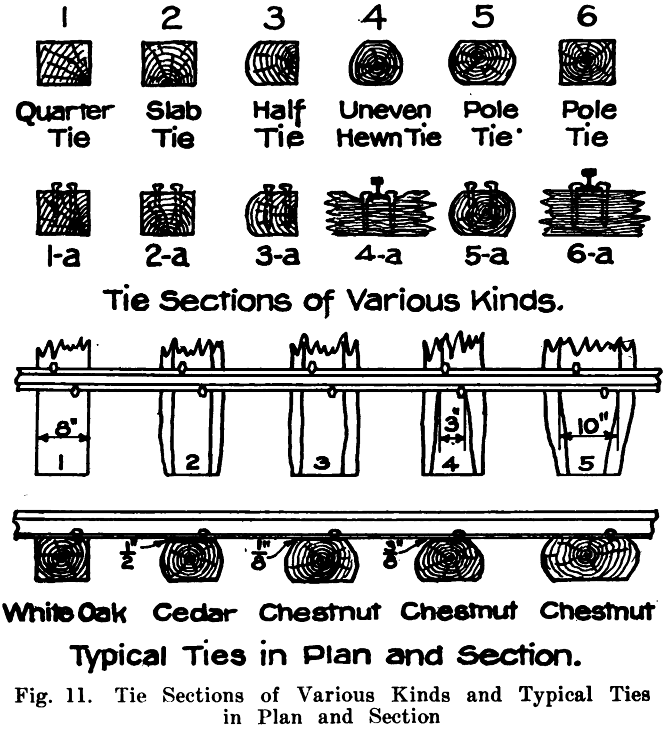


Fig. 11. Tie Sections of Various Kinds and Typical Ties in Plan and Section

will not require so soon the use of plates on tangents, whereas the other ties should have tie plates, if sap is placed up, to prevent their being cut into.

In the lower part of Fig. 11 is shown, first, a white

oak tie, a cedar, a chestnut, a narrow-faced chestnut and a wide faced chestnut tie. It will be noticed from the shading, which indicates the amount of wear from the base of the rail, that the white oak tie is cut but little, the cedar and narrow-faced chestnut the most. If ties thus placed were of different wood or of different face this would occasion an uneven bearing for the rail when the wheels are upon it.

There is also an objection to narrow and wide faced ties being placed near each other, especially in track under an overhead bridge, owing to the fact that frost will hang under the wide-faced ties and come out quickly under the narrow-faced ones, making uneven riding track in the spring. Above the sections in the lower part of Fig. 11 is shown a rail spiked to the ties showing the tie face.

In the tamping of track, a hewn tie can be worked more rapidly to a good bed than a sawn tie. Other things being equal, a railroad which is not compelled to renew its track ties for nine or ten years after they are laid, has an immense advantage over a road that must renew its ties once in five years. The latter road must figure into its expense account almost double the cost for material, besides the additional track labor necessary to do the work, and during the interval it cannot have as good a track as the former. Ties sawn square will rot sooner and break more easily than hewn ties, and are generally too small to give a good bearing surface. Pole ties, with a face on two sides, made by sawing slabs from them, are generally good and preferable to quarter ties or those split out of very large logs, because the wood of a big tree is more brittle than that of the younger growth. A well hewn pole tie, with a face on two sides, eight or ten inches wide, is preferable to all others for track purposes.

Dimensions of ties. The following table shows the

sizes of ties specified for a first class line, the eight and a half foot ties being used on main tracks and the eight foot ones in sidings and yards, but in some cases the eight foot ones are used on main track of branch lines if the traffic is not so heavy as to warrant the use of the larger class.

Tie sizes.

Length	Kind	Thickness	Face First Class	Face Second Class
8½ feet	Pole ties	7 inches	7 inches	6 inches
8½ "	Split "	7 "	9 "	7 "
8½ "	Saw "	7 "	9 "	8 "
8 "	Pole "	6 "	7 "	6 "
8 "	Split "	6 "	8 "	7 "
8 "	Saw "	6 "	8 "	7 "

Face must not be less than specified. Variations in thickness of one-quarter inch under or over will be permitted and, in length, one inch under or over.

The life of a track tie is not altogether dependent upon the kind or quality of timber used. The same kind of tie will last longer in the North where the ground is frozen all winter, than in the South, where the process of decay goes on uninterruptedly; there is also a marked difference in the effect on ties of an extremely wet or dry climate and the amount of traffic over them. If the length of ties equalled twice the gage of a track, they would give much more support to the rail. As it is, the ties receive their main support from the inside and only a proportion from the outside ends. This condition has a tendency to develop swings and rough track. If the rail received as much support from the outside as from the inside and the support provided by the ballast were uniform, the ends of the ties would not be so likely to spring up and down under a passing train and there would consequently be no space between the ends of the ties and the ballast beneath for water to get into,

but the ties would rest solidly on their foundation from end to end.

Distribution of new ties. In renewing ties by the "spotting method" as is the general practice and not "out of face," each mile of track will require approximately the same number of ties each year, but of course if track has recently been ballasted or relaid with new rail and the tie renewals have been generous where the new rail was laid only light renewals will be necessary for the next few years. Ties to be used during the season may come for distribution the winter before but there is no difficulty in approximating the number required in each mile of track, and arrangements should be made to distribute them accordingly, that they may be available for use without rehandling. If there are enough cars of ties to make a day's work for a work train, all the better, otherwise a few cars of ties and some other work may go to make up a train. In any event, it is economical to get the ties to the point where they are wanted in the first place. If there are not ties enough on hand to warrant the ordering out of a work train, the service of a way freight can usually be secured to release cars promptly.

When new ties are unloaded from cars the foreman should see that any of them that are too close to the track are removed to a safe distance immediately after the passage of the unloading train.

Piling ties. The usual practice is to put fifty ties in a pile. Some roads place them in square piles while others pile them in pyramids or A-shaped piles at right angles to the track. See Fig. 12 for Correct and Wrong Methods of Piling Ties, indicating P. R. R. practice, as given in the Ry. Age Gazette, Feb. 19, 1915.

Tie inspection. Large railroads usually have a system of marking for the foreman the ties which are

to be renewed on his section during the season. This is done early in the spring or as soon as the frost is out of the ties by the tie inspector, who goes over every mile of track and marks with white paint the rail over the ties that it is considered necessary to renew. Ties that are questionable are tested with a pick to ascertain the extent to which they are decayed and a record is kept of the number to be renewed in each mile or quarter mile, showing how many are on curves and how many on tangent. The record is

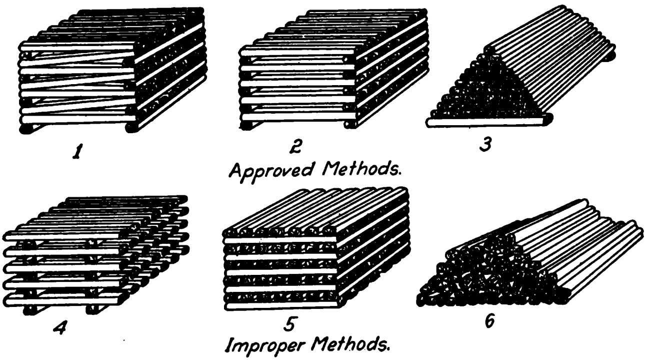


Fig. 12. Methods of Piling Ties

kept on blanks provided for the purpose, and knowing the total number of ties in track in each mile the percentage of ties renewed each year is readily ascertained. If the foreman makes any change in the number renewed from those spotted he makes a report giving the reason therefor. Also, the number of new ties on hand in each mile available for use is tabulated and from this information the supervisor or roadmaster knows how many additional ties must be distributed to complete the renewals. The tie inspection work is usually delegated to an experi-

enced foreman whose judgment is good in this line, and necessary assistance is furnished him while on this work temporarily, but some roads insist on the supervisor doing it personally so that he will be thoroughly acquainted with the tie conditions on his subdivision. When practicable it is best to have the section foreman along, too.

Renewing ties. When putting ties under the track the foreman should never allow the men to dig out any more than is necessary to allow the tie to go under easily. The old bed should not be disturbed if the new tie will fit. A good method for putting in ties where two together are to be renewed is to dig out between the two and on each side of the track, a little deeper than the bed of the ties, remove the spikes from the old ties, knock the old ties into the hole, and pull out. Pull the new tie into the same hole from the opposite side of the track, if it is of about the right size, and let a man on each side of the track slide the tie into its bed, keeping it close up to the rail until in its place.

Tie gage. New ties should always be spaced evenly; they should be square across the track and laid so that the center of the tie will coincide with the center of the track; this will leave the ends so that they will not line up perfectly one with the other on account of the slight variation in length of ties, but this is hardly enough to be noticeable and there is considerable question as to which looks better after all, a track with ties evenly lined at one end and ragged on the other or where the variation is the same in the line of both ends. It is best to have wheel loads supported equally at the two rails and this is best accomplished by having the ties centered. Also, where, for instance, 8½ ft. ties are adopted for renewal on a line already equipped with 8 ft. ties, a

presentable appearance still obtains if all ties are uniform with the center line of track.

In order to get the tie into this position without any extra measuring, a tie gage or stick say 1″ x 2″ should be provided which has marked upon it the length of the tie being used and the locations of the two rails; it is then only necessary to lay the gage on

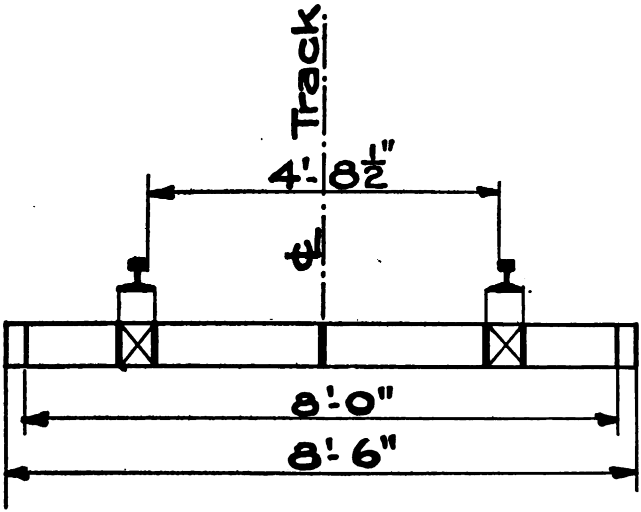


Fig. 13. Tie Gage, Made of 1″x4″ Board

the tie to be installed and mark with chalk the location of the base of each rail and see that the marks so made come to the rails when the tie is being spiked. The tie gage saves an endless amount of work both in renewals and especially in construction of new tracks where a man marks the position of the rails as fast as the ties are distributed out ahead, thus greatly helping the spikers.

Selecting joint ties. Under joints where angle bars are used, put in two well-hewn ties of about equal size, and have each tie come well under the angle bars, as this is the first consideration. The other ties are spaced to suit the joint ties.

The number of ties used per rail length depends somewhat on the size of the ties, whether the general run of them is large or not. A good way to roughly space ties is to have them just far enough apart to enable a track shovel to be passed between them when held sideways. This will give about the proper space for tamping. Where there are wide spaces between existing ties, an extra one should be put in and the adjoining ties shifted as necessary to divide up the space. For a thirty-three foot rail length, an average of eighteen good sized ties makes good track. Ties sawn square should not be put under a rail joint if it can be avoided. When putting in ties a foreman should arrange his gang in such a way that all can be working at once, having each man do the work he is best suited to perform. When working a large number of men he ought to have tools enough to work them in separate gangs, because in this way more work can be done in proportion to the number of men employed. However, with section forces making tie renewals it is not often advisable to divide up the gang, but if track is in poor condition as to ties other gangs can be added as necessary.

Finish as you go. The tie renewals when once started should be prosecuted continuously and with as little interruption as possible to take care of corrections to surface, line or gage that cannot wait, of course changing out rails that show signs of failure. It is best to begin the tie work at the end of section farthest from the foreman's headquarters and work toward the tool house if possible, but it is also well

to have adjoining sections start together at the section line and work apart, thus giving the large amount of repaired track in one place.

Two kinds of foremen are in the railroad business today. One is represented by the man who does exactly what he is told in the manner in which he has been instructed; the other carries on what he understands to be the intention of the superior officer, in such a manner that it will pass inspection, but he tries to do it in a brand new way, or at least in a way different from the one that has been indicated to him as satisfactory by his supervisor. This kind of man fails to realize that there may be reasons for the instructions that are given him, of which he does not know, but no one has had time to explain to him. The first rule is to do exactly as your superior officer tells you to do, exactly the way in which you think he would do it if he were there to do it in your place. The foreman who can follow this rule and does conscientiously follow it will get along a good deal faster in the railroad business than the other foreman who thinks that a second rate new-fangled method is better than a first rate old one.

As soon as new ties are installed in place they should be tamped and spiked, putting on tie plates if required at the same time. It is not good practice to open up and weaken a lot of track and let the new ties go unspiked until you can make a general job of spiking, but when one or two are applied they should be spiked at once. The neglect of this rule has been the cause of serious accidents. Fill in the ballast that has been removed, and dress up generally as you go so that if called away at any time on other work you will leave good, safe track.

Remove the bark. The bark should be removed from all hewn or round timber used in railroad con-

struction, before it is put into service. If allowed to remain it retards the evaporation of moisture and thereby hastens decay.

Bridge piles will remain sound longer if the bark is removed. The same may be said of fence posts. Considerable loss of strength is occasioned by the failure of nails or other fastenings to secure a firm hold on the wood where they are driven through the bark.

In the case of track ties, the bark not only causes decay but is a source of annoyance in tamping or repairing the track and dangerous on account of fire. The best plan is to have, in the specifications for ties delivered by contract, a clause that they have all bark removed.

When new ties are being placed in position they should not be damaged by using picks or other sharp pointed tools. Tie tongs, such as are now on the market, afford a satisfactory method of handling ties without injuring them.

Ties in highway crossings. When renewing ties, the trackmen should not overlook highway crossings, where it is necessary to take up the plank, examine closely as to their condition, and make whatever renewals are necessary.

Renewing ties when ballasting. When ballasting with gravel, stone or other material, the ties in need of renewal should be changed out, as the work is more easily done then and the cost is less. It is well to make such renewals that the track will not have to be disturbed for two or three years. If any ties so removed are found to be in fair condition they can be turned over and used in nearby sidings.

Renewal methods on various roads. A very interesting method and blank forms for keeping tie renewal reports on different roads were published in the Ry. Age Gaz. for May 21, 1915, the accompanying description reading as follows:

"The latest official statistics show that the railroads spend annually about $55,000,000 for the ties used to replace those removed from the track on account of wear, decay, accidents, etc. This figure, which does not include the cost of labor for distributing the new ties, placing them in the track and disposing of the old ones, together requiring so large a part of the trackmen's time during the spring and summer, is about 15% of the total cost of maintenance of way and structures and 3% of all operating expenses. It is obvious then that particular care is justified to insure the lowest percentage of renewals consistent with proper maintenance standards; and important as this subject is at present, it is becoming increasingly so on account of the rapidly increasing cost of ties.

"Theoretically, to attain the maximum economy every tie should remain in the track until it reaches the point in its deterioration when it will no longer support the rails with the proper factor of safety, and should then be removed immediately. Practically, since ties are renewed once a year it is the general rule to remove all that will not safely carry the loads for another year, and on account of the disadvantages resulting from tearing up the roadbed, to a certain extent ties with even a greater life than this are renewed during general surfacing, re-ballasting or rail renewal.

"Some roads have tried to assign a reasonable number of ties to each section and leave it to the foremen to use them to best advantage, but the imperfections of this scheme are obvious. It is almost universal therefore to base the requisition for ties on an inspection of the track prior to the season of renewal, although the methods of making this inspection, of checking the reports and of supervising the work of placing the new ties in the track vary widely. These

differences as they exist on 16 typical important roads are discussed in the following paragraphs.

"**Inspection and marking.** The inspection upon which the requisition and allotment of new ties is made is left to the section foremen on the Central Railroad of New Jersey with very satisfactory results. The supervisors are constantly in touch with the foremen, walking each section during the year and familiarizing themselves with the details. Each foreman is allowed to ask for as many ties as he thinks he will require. These data are then checked up by the supervisors, who have acquired during the course of the year an approximate idea of what the needs of each section will be. The requirements are then forwarded to the Engineers Maintenance of Way, who tabulate the data and make requisition for the necessary ties. After renewals have started, the supervisors and assistant supervisors examine all ties removed very carefully, and if a foreman is found to be removing too many ties, or leaving poor ties in the track, his attention is drawn forcibly to the fact. The Engineers Maintenance of Way as well as the Superintendents also inspect ties that are removed at frequent and unexpected intervals in their trips over the line. Any ties removed from the track that are found to have any additional life are sorted and picked up by the work train and used in siding repairs or construction, being spotted in with good or new ties. Under this system the situation has gradually improved until it is scarcely ever necessary to draw a foreman's attention to any misjudgment, and much better results are being secured than by methods previously employed. The objection to leaving the selection of ties to be removed from the track entirely to the section foreman, which is advanced by some maintenance men, is that there is too great a tendency under this method to praise the man who

puts in the most ties per day per man, resulting in the removal of some ties from which additional life could be secured.

"Several roads have found it advantageous to combine the detailed inspection of the foremen with check inspections by supervisors, roadmasters, engineers or superintendents. On the Boston & Albany the foreman's statement is checked up by the supervisor or his assistant and is then sent to the division engineer for approval. On the Pennsylvania the practice is similar except that the division engineer, usually accompanied by the supervisor, also makes frequent independent inspections to see that the proposed renewals are proper and economical. In addition, there are men assigned to special duty both on the division and in the office of the Engineer Maintenance of Way, who regularly follow up tie renewals, making an inspection both of the ties removed from the track and those left in. These men submit reports on what they find and any cases of bad judgment are taken up through the regular channels. During the time that this practice has been followed, covering the last six or seven years, there has rarely been any cause for criticism.

"The reports of the Northern Pacific section foremen are checked by the roadmasters walking over a part of each section, and in addition the division superintendent goes over at least three sections on each roadmaster's district accompanied by the roadmaster on a hand car or on foot to verify the tie requirements. The Illinois Central requires the supervisors, after receiving the foremen's reports, to make an independent inspection and then forward the foremen's reports with their recommendations. The roadmasters, on receipt of the supervisors' reports, check the judgment of their men.

"Some roads place the responsibility for the tie in-

spection entirely on the supervisors or roadmasters. Such roads include the Atchison, Topeka & Santa Fé, the Norfolk & Western and the New York Central. On the Baltimore & Ohio all tie inspections are now being made by the supervisors, and a general tie inspector for the system checks up these reports. This method has been found better than a previous one in which tie inspectors alone handled this work. Other roads, including the Chicago & North Western, the New York, New Haven & Hartford, the Philadelphia & Reading, the St. Louis & San Francisco, and the Union Pacific, require the roadmaster or supervisor and the section foremen to go over the line together for the inspection of ties to be renewed, thus combining the broader experience and better judgment of the superior officer with the detailed knowledge of local conditions possessed by the foreman.

"On two of the roads considered, the tie inspector is used with satisfaction. The Queen & Crescent inspectors are selected by the roadmasters and report to them.

"They are accompanied in making their trip over the line by each supervisor while working on his district. The Buffalo, Rochester & Pittsburgh selects the most intelligent extra gang foremen for tie inspectors, making them report to the division engineers. They are accompanied by the section foremen in going over the line. The roadmasters and foremen are not relieved of responsibility for the safety of their track on this road and are given a proper voice in the matter of tie renewal.

"The time of making tie inspections is also extremely variable, so that considering April 1 as the beginning of the tie renewal season, the inspection is begun on some roads as much as nine months before that date and is not finished on others until three months after it. The Boston & Albany and the New

York Central are among those that begin early, the former making its inspection during July and August, and the latter usually finishing it before October 1. The Union Pacific, the Chicago & North Western, the Pennsylvania, the Central Railroad of New Jersey, the St. Louis & San Francisco, and the New Haven require the inspection to be made during the fall, and the Queen & Crescent specifies December. On the Baltimore & Ohio the work is begun as soon as possible after January 1 and is completed before July 1. The months of April and May are designated for tie inspection on the Illinois Central, and on the New Haven and the Buffalo, Rochester & Pittsburgh, the work is handled during the spring, beginning on the latter road as soon as the frost is out of the ground.

"The points to be considered in an inspection of ties in the track may be left entirely to the judgment of the inspector or be covered more or less completely by written instructions, depending on the practice of the individual roads. When such instructions are brief they ordinarily mention a close examination including the ties on each side of the one under consideration, the local roadbed conditions, the location, whether in curve or tangent, the amount and character of the traffic, the visible rot or crack, and a test with an adze or other suitable tool to determine interior soundness. A very complete set of instructions is issued to the tie inspectors on the Buffalo, Rochester & Pittsburgh, from which the following abstract is taken:

"There are two standards for making renewals in main track; first, where the track is not to be disturbed and the ties will therefore be dug in and, second, where the track is to be raised off of the old bed allowing the ties to be placed during the raise. Under the first condition ties must be inspected by driving

a pick in each side adjacent to the rail seat near both the bottom and the top faces below the sap line. The pick must be driven into the ties toward the center and be drawn with as little prying as possible. The ties must not be tested on the top except in an endeavor to find decay around the tie plate and spike, and in such tests the ties must not be mutilated more than absolutely necessary. To test the tie for strength, one end of a pick should be inserted under the end of the tie and the pick used as a lever. If the tie is broken under the rail seat this will usually determine it. If two ties with only one year's safe service are adjacent, one must be removed. In a group of ties, all of which have only one year's safe service, enough must be renewed to leave each doubtful tie with one good neighbor. Sap rot alone is not sufficient to condemn a tie. A tie cut down by rail wear should not be renewed unless the rail has cut into the face more than ¾ in. This applies to ties on tangent, as all curves are tie plated. On curves when by being adzed repeatedly for rail renewal a tie is cut down sufficiently to weaken it, it should be removed and used for side track renewals if the timber is sound. On tangents where a good tie is cut down ¾ in. by rail wear or adzing it should be protected with tie plates against further cutting. Careful attention must be given to the inspection of red oak and pin oak ties, as this timber usually rots from the center, leaving a hard shell which can be detected only by careful inspection. In track that is subject to heaving and where shimming is necessary, care must be taken to insure enough good ties for spiking and bracing, and special attention must be given to the inspection of ties through road crossings, station platforms and other places where they are covered and likely to be overlooked by the section men.

"The second condition governing the marking of

ties for renewal arises from the policy of the company to resurface out of face a part of the main line on each section each year in addition to the reballasting of track when new rail is laid. In such cases it is the intention to make sufficient renewals to last two or three years without having to disturb the track

FORM [illegible]

BUFFALO, ROCHESTER & PITTSBURGH RY.

ENGINEERING DEPARTMENT

FOREMAN'S DAILY REPORT OF TIES PUT IN TRACK

Date ______________ 191__ | Division ______ | Section ______ | Mile Post ______________ to Mile Post ______________

LOCATION	T	E	RO	BO	PO	M	B	Br.	Cr.	G	C	H	P	[illegible]	REMARKS
North Bound Track															
South Bound Track															
Single Main Track															
Side Track No.															
Side Track No.															
Side Track No.															
No. 7 Switch Set															
No. 7 Switch Set															
No. 8 Switch Set															
No. 8 Switch Set															
No. 9 Switch Set															
No. 9 Switch Set															
No. 12 Switch Set															
No. 12 Switch Set															
No. 7 Xover Set															
No. 9 Xover Set															
No. 12 Xover Set															

Correct ______________ ROADMASTER

Signature ______________ SEC. FOREMAN

INSTRUCTIONS—Section Foreman must fill out one of these reports covering ties put in main tracks and sidings for each mile, and mail to Roadmaster at close of each day. Note opposite each switch and crossover set, under proper Heading, the number of pieces of each kind of timber, and show station and side track number where located. Show station where each side track is located in remarks column opposite.

Fig. 14. The B. R. & P. Foreman's Report of Ties Put in Track

during that time. Under this condition the inspectors test the ties as previously described, removing all that will not last more than two years. Where new steel is laid, no bad ties must be left under the joints. In making renewals in this case, some fairly good ties may be taken out, in which case they should be care-

fully sorted and piled, to be picked up and distributed for side track renewals. A lower standard of inspection is used for mine tracks and side tracks, and especially for standing tracks in yards where no ties are taken out until their safe service is passed. In passing tracks care should be used to see that all ties around turnout curves are in good condition.

"Although a large majority of the roads considered require the officer making the first inspection to mark each tie in some distinctive manner for future identification, several roads, including the Pennsylvania, the Union Pacific and the Central Railroad of New

BUFFALO, ROCHESTER & PITTSBURGH RAILWAY
ENGINEERING DEPARTMENT
FOREMAN'S DAILY REPORT OF TREATED TIES TAKEN OUT OF TRACK

LOCATION	T	E	RO	BO	PO	M	B	Br	Cy	G	C	H	P	REMARKS
North Bound Track														
South Bound Track														
No. 12 Xover Set														

Correct | Signature

INSTRUCTIONS—[illegible]

Fig. 15. A Report Covering Treated Ties Taken Out of Track

Jersey use no system of marking. The two commonly recognized methods of designating ties for renewal are by cutting with an adze or axe, and by painting a line on the web or base of the rail directly over the tie. Various forms of cutting are in use, such as chipping off one corner, and notching the side or top of the tie, while on the Northern Pacific two gashes about 3 in. apart are cut on the side near the end. The Buffalo, Rochester & Pittsburgh, the Queen & Crescent, the Baltimore & Ohio, and the Atchison, Topeka & Santa Fé use paint.

"**Renewals and records.** On the Union Pacific it

is the practice to distribute enough ties before March 1 to care for the renewals on each section up to June 30, the remainder being piled in yards and distributed after July 1, so as not to interfere with the mowing of the right of way. The roadmaster selects the locations at which the renewals are to be made each month and inspects the ties after renewal. On the Pennsylvania the foreman "blazes" or marks with kiel the ties that are to come out just previous to their renewal. The ties removed are held for inspection and the good ones returned to side tracks, the rest being burned or destroyed. On the New York Central the foremen are instructed to avoid as far

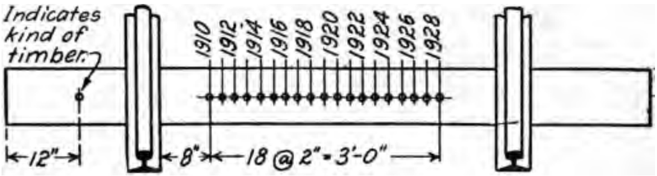
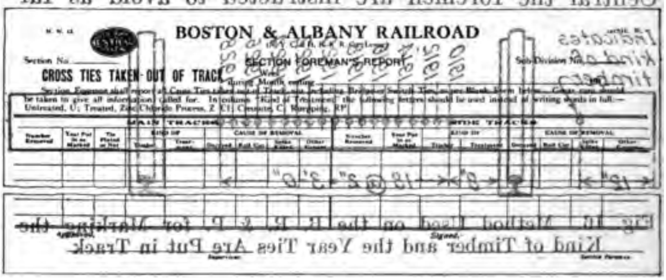


Fig. 16. Method Used on the B. R. & P. for Marking the Kind of Timber and the Year Ties Are Put in Track

as possible the renewal of ties to face and they are cautioned particularly against damaging the ties by picks or by hammering them in spacing. Tie tongs are furnished on all sections where treated ties are used and tie plugs are required to be driven in the holes whenever a spike is drawn. To reduce the tendency to decay around the holes these plugs are treated.

"On the Queen & Crescent the foreman, during the renewal of ties, examines carefully each tie spotted for renewal by the inspector and leaves in the track any that he thinks will last another year. He also reports any ties not spotted that he thinks should be removed, giving their location, but waiting for authority from

the roadmaster before taking them out of the track. On the B., R. & P., the foremen renew only the ties spotted by the inspectors on track that is not to be raised. In case they think additional ties should be removed they report to the roadmaster, who has the ties reinspected. In track that is being raised the foremen are allowed to remove unmarked ties which should come out, placing a cross on them for special inspection later. Such ties are used again if possible. The inspectors on this road are instructed to watch carefully the practice of section forces in renewing ties and to report any improper practice. It is cus-


BOSTON & ALBANY RAILROAD

SECTION FOREMAN'S REPORT

Section No.

Sub-Division No.

CROSS TIES TAKEN OUT OF TRACK

Fig. 17.—The Boston & Albany Form for Reporting Cross Ties Taken Out of Track.

tomary on most roads to pile and burn the ties removed after proper inspection to secure ties that may have additional life in side tracks or yards. Special precautions are necessary in burning ties to prevent fire damage to the telegraph line, right of way fences, and adjacent property.

The number and kinds of records of tie renewals kept for future reference differ considerably on the roads considered. These permanent records are kept by various officers ranging from the division engineer to the general manager, and the records may be in-

tended simply for a check of the actual renewals with the requisition or for comparisons of the renewals of each mile for a period of years to make possible close supervision. On the Union Pacific each roadmaster is given a table showing the number of ties that can be used each month to avoid getting the expense for all renewals in one month. To supplement the record turned in by the inspector, the foremen on the Queen & Crescent are required to make a monthly report to the roadmaster showing the number of ties on each mile spotted for renewal but found good for another year and also the number not spotted but removed, with the cause of their removal. The Boston & Albany keeps a record by weeks of all ties taken out of track on the forms reproduced herewith.

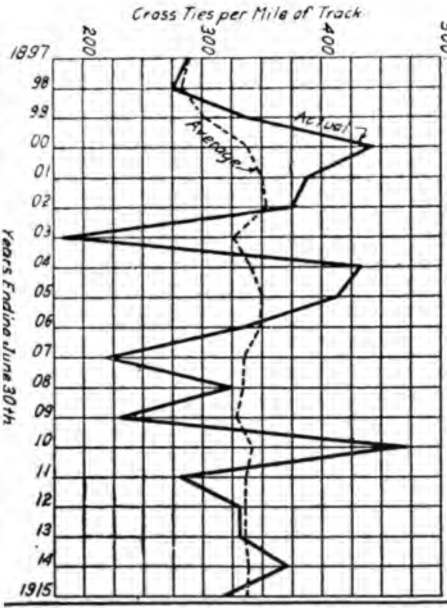
The C. B. & Q. R. R. requires a daily report from foremen showing ties put in the track and treated ties removed. This information is furnished on the blanks reproduced herewith, and tabulated in the office of the chief engineer in book form by weeks. The treated ties on this road are marked at the treating plant by a galvanized nail bearing letters indicating the kind of timber, which are driven in the upper face of the ties 12 in. from one end. When the ties are placed in the track a similar nail bearing the date is placed in the upper face of the tie between the rails, the position along the tie also being varied by an increment of 2 in. for each year. On the Baltimore & Ohio the record of ties marked for renewal is transferred in the office of the division engineer to forms covering main and side track, tie inspection and renewals, blue prints of which are sent to the Engineer Maintenance of Way through the office of the District Engineer Maintenance of Way immediately upon the completion of the inspection for the divisions. During the season of renewals the foremen report monthly on the ties removed from track, this report

accompanying and checking the material report. This information is also entered on the forms mentioned above, furnishing a complete record of the renewals of the year by miles.

"On the Illinois Central a record is kept in the office of the chief engineer of all ties used each year for construction and maintenance and also a special graphical record of the renewals in main track. Each district has a separate chart, and these are bound in book form. A book covering the entire system is kept in the office of the chief engineer and one covering each division is furnishd to the division superintendent. As soon as the recommendations for tie renewals are made they are plotted on the chart and when any important difference from the accumulative average is shown an investigation is immediately made by an assistant engineer from the office of the Engineer Maintenance of Way or by an old roadmaster selected by the Engineer Maintenance of Way on account of his previous good record in tie renewals. The curves shown herewith illustrate the manner of keeping this record for a typical division (Fig. 18).

"In determining the average number of ties per mile used in renewals each year, a correction is applied in cases where new lines have been constructed, so that the average derived furnishes a comparison of the renewals on all divisions regardless of the date the line was constructed. The mileage of new track is therefore added not in its entirety the year the line is built but in sections during the period of nine years. The amount added each year is proportionate to the estimated tie renewals required for that year. The first addition is made during the third year, amounting to 2 per cent, the remainder being added as follows: fourth year 3 per cent, fifth year 5 per cent, sixth year 5 per cent, seventh year 25 per cent, eighth year 50 per cent, and ninth, 10 per cent.

On account of the increased average life of ties resulting from the use of tie plates and preservative treatment these percentages will be revised in the near



Year	Average per Mile.	Accum. Av. per Mile.	Miles	Ties.
1897	278	288	407.26	117455
98	278	283	480.66	133909
99	336	302	480.96	161857
00	444	339	481.31	213903
01	389	350	481.94	187899
02	373	353	482.96	179960
03	178	327	485.60	85991
04	434	341	491.36	213139
05	412	350	504.31	208046
06	334	348	512.68	171388
07	215	335	519.92	111772
08	324	334	538.22	174183
09	278	329	568.84	158399
10	471	341	585.64	275531
11	280	336	604.21	169427
12	331	335	602.84	199960
13	332	335	604.80	200559
14	338	372	608.65	226484
1915		317	610.00	193612

Fig. 18. A Chart Kept by the Illinois Central, Showing the Actual Annual Consumption and the Accumulative Average Annual Consumption of Ties Per Mile of Main Track on One Division

future. Two averages are shown on the chart, the solid line representing the average ties per mile used in renewals in the years shown, and the dotted line the accumulative average per mile used in renewals

since 1893, the year in which the chart begins. The actual number of ties used each year is shown at the top of the chart and the scale of miles is corrected, not actual.''

Economy in the use of treated ties and the comparative cost of treating seasoned and unseasoned ties. Mr. F. J. Angier, Superintendent Timber Preservation, Baltimore and Ohio R. R., read a paper at the eighth annual meeting of the American Wood Preservers' Association at Chicago, from which we quote the following abstract:

"When we speak of an unseasoned tie, we mean one freshly cut, or, at least, one that has been recently cut and has lost but a very small amount of the moisture which it originally contained; in other words, the sapwood is so completely filled with moisture that it would be impossible to thoroughly treat the tie until this moisture had been at least partially removed. A seasoned tie, therefore, is one that has been cut for some time and the moisture allowed to evaporate to a greater or less degree. The time necessary to season a tie so that it can be properly treated varies in different localities, as well as in different seasons. The kind of wood also is of considerable importance. Oak ties, in Illinois, must be air-seasoned six months or more, according to the time of year, before they can be properly treated. Some kinds of ties may be seasoned in three or four months.

"For the purpose of illustration we will assume that it requires six hours to treat a charge of thoroughly seasoned ties and nine hours to treat a charge of unseasoned ties. Of course, the time may vary one way or the other, but we found this to be a fair average. (It should be stated here that the treatment referred to is with a mixture of creosote and zinc chloride, known as the card process.)

"Assuming this to be correct, attention is called to

the two tables following, one showing the cost of treating in a plant having a maximum capacity of 1,800,000 seasoned ties a year, and the other the cost of treating in the same plant, where the maximum capacity is reduced to 1,200,000 unseasoned ties a year.

COST OF SEASONED TIES; TREATING CAPACITY OF PLANT, 1,800,000 PER YEAR

Unloading from cars to ground to season at $0.0070 each	$ 12,600.00
Loading from ground to trams at $0.0055 each	9,900.00
Switching trams at $0.0020 per tie	3,600.00
Loading treated ties out at $0.0065 each	11,700.00
Fixed expenses	23,268.00
Preservatives at 15 cts. per tie	270,000.00
Fuel (assume 1/3 less for seasoned over unseasoned ties)	5,600.00
Insurance carried on 1,000,000 ties (estimated)	4,000.00
Interest on 1,000,000 ties for six months, or 5 per cent on $250,000.00	12,500.00
	$353,168.00
600,000 more seasoned ties treated than unseasoned, worth $0.044 each per year extra (see statement)	26,400.00
	$326,768.00
Cost per tie	$0.1815

COST OF UNSEASONED TIES; TREATING CAPACITY OF PLANT, 1,200,000 PER YEAR

Unloading one-fourth from cars to ground to enable prompt releasing of cars at $0.0070	$ 2,100.00
Loading 900,000 ties from cars to trams at platform and 300,000 ties from ground to trams at $0.0055	6,600.00
Switching 300,000 ties from yard to retorts at $0.0020	600.00
Loading ties out at $0.0065 each	7,800.00
Fixed expenses	23,268.00
Preservatives at 15 cts. per tie	180,000.00
Fuel	8,400.00

Insurance carried on 300,000 ties (estimated)....	1,200.00
Interest on 300,000 ties, or 5 per cent on $75,000.00	3,750.00
	$233,718.00
Cost per tie	$0.1948

"In each case the total cost of handling is shown from the moment the ties are received at the plant until they are loaded into cars for shipment. In the case of fixed expenses there are included the salaries of the superintendent, general foreman, office force, engineeers, firemen, etc.; that is, all labor which would not change one way or the other, whether treating seasoned or unseasoned ties. This amounts to $0.0129 per tie when treating 1,800,000 ties per year, and $0.0194 when treating 1,200,000 ties per year. In the case of seasoned ties, where no steaming is done, it is assumed that insurance is carried on 1,000,000 ties for six months and that $250,000 will be continually invested at 5 per cent. In the case of unseasoned ties, we must assume that at least 300,000 will always be in the yard. This stock is necessary to provide against delay to plant at certain times of the year, when traffic is so great that company material cannot be moved with regularity. Also, at certain times of the year, ties will be received faster than they can be treated, necessitating the storing of a portion of them.

"It is shown in the table that a treated tie is worth $0.044 per year to the company more than an untreated one. This figure is obtained as follows:

Untreated Ties—

First cost	$0.50	
Cost of putting in track	.15	
Cost of tie in track		$0.65
5 per cent interest on investment for six years		.195
Second renewal, end of six years		.65

5 per cent interest on first investment for six years, and on second investment for six years		.39
Total cost of tie for period of 12 years		$1.885
Average cost per tie per year		$0.157
Treated Ties—		
First cost	$0.70	
Cost of putting in track	.15	
Cost of tie in track		$0.85
5 per cent on investment for 12 years		.51
Total cost of tie for 12 years		$1.36
Average cost per tie per year		$0.113
Saving per tie per year, $0.044.		

"Untreated ties are assumed to last six years, and treated ties twelve years. Assuming this to be reasonable, and that 600,000 more ties per year can be treated when thoroughly seasoned, deduct from the cost of seasoned ties the difference between 1,800,000 ties and 1,200,000 ties, or 600,000 ties, at $0.044 each, and we have a difference of $0.0133 per tie in favor of treating seasoned ties.

"In addition there would be a better penetration of the preservatives; therefore a longer life obtained for the ties and the lessened possibility of injury to the wood by steaming. When steaming there is always a large amount of sewage to dispose of, while in non-steaming there is practically none. The disposition of sewage is a difficult problem at most plants, because no matter how it is handled some of it will get into the rivers or creeks and pollute the water to such an extent that damage suits may result. This is entirely avoided when using seasoned ties."

IV

CUTTING WEEDS

Points about weeding. On embankments, the weeds should be kept down with a scythe or brush hook, as far out as the right of way limits, if the foreman is allowed men enough to perform this work without neglecting the track or other necessary work. A clean track is not necessarily a safe track, and a foreman should not have his men mowing grass and weeds along the right of way, unless the help he is allowed and the condition of his track at the time will permit it. When weeds are cut in the center of an earth ballasted track or on an embankment the earth that is picked up by the shovel together with the weeds should not be thrown down the embankment, but should be turned over and allowed to remain where it was originally. The practice of shaving off the embankment one or two inches every time weeds are cut is bad, since the loose earth thrown down the hill soon washes away, and each additional weed cutting of this kind weakens the shoulder, makes the fill narrower, and in time allows the ends of the ties to project over the bank and the track to settle for want of a sufficient support.

In connection with this subject attention may be called to the fact that extensive experiments have been made on some of the prominent roads by sprinkling the roadbed with oil, for the purpose of preventing the raising of dust by fast trains. The observed effects have been very gratifying. Not only does the oil pre-

vent the former clouds of dust, but it has proven useful in other ways. The oil acts as a tie-preserving agent, and to a certain extent prevents water from soaking into the roadbed, and finally discourages the rapid growth of grass and weeds. The oil is applied

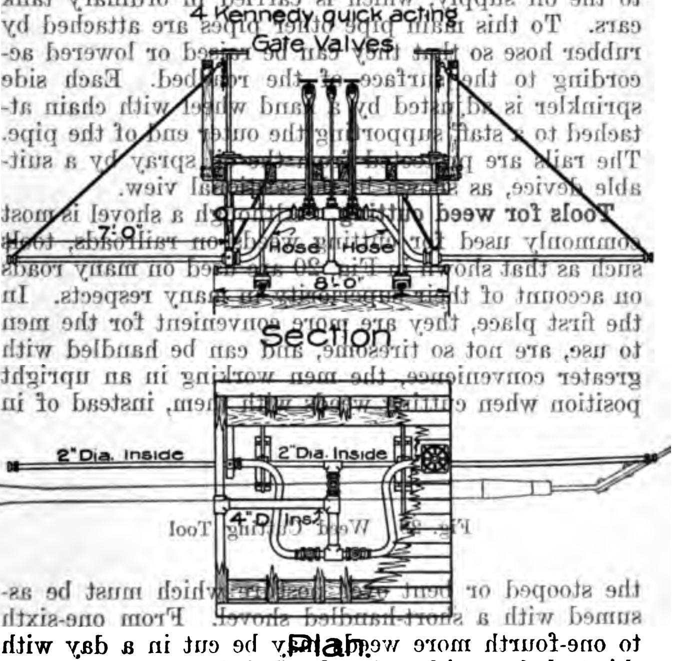


Fig. 19. Section and Plan of Q. & C. Sprinkling Car

on cinder, sand, gravel, or earth ballast, with equally good results, and many western roads are making extensive tests both to destroy the weeds and grass, and to prevent the heaving of track by frosts. Any development that will relieve the track department of

weed cutting and at the same time allay the dust will meet with general approval.

We show herewith in Fig. 19 a section and a plan of the Q. & C. oil sprinkling car. A 4-inch pipe runs the full length of the car with rubber hose attachments to the oil supply, which is carried in ordinary tank cars. To this main pipe other pipes are attached by rubber hose so that they can be raised or lowered according to the surface of the roadbed. Each side sprinkler is adjusted by a hand wheel with chain attached to a staff supporting the outer end of the pipe. The rails are protected from the oil spray by a suitable device, as shown in the sectional view.

Tools for weed cutting. Although a shovel is most commonly used for cutting weeds on railroads, tools such as that shown in Fig. 20 are used on many roads on account of their superiority in many respects. In the first place, they are more convenient for the men to use, are not so tiresome, and can be handled with greater convenience, the men working in an upright position when cutting weeds with them, instead of in

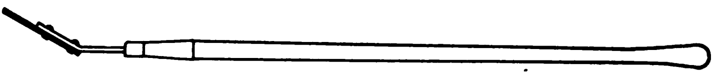


Fig. 20. Weed Cutting Tool

the stooped or bent over posture which must be assumed with a short-handled shovel. From one-sixth to one-fourth more weeds may be cut in a day with this tool than with a shovel. It is less expensive than a shovel, and the dirt or ballast that would be lifted by a shovel and wasted by careless men is not disturbed by the tool shown, when weeds are cut, but remains in its original position in the track or on the shoulder of the embankment. This last advantage alone is a sufficient reason for its general introduction

on all roads where extensive weed cutting is necessary.

The weed cutting tool should have a blade made of very thin, hard steel. The blade of the hoe, as manufactured for garden use, when properly tempered, is the correct thing, because, although the edge gradually wears away, yet it never requires sharpening, as would be the case with thicker blades on account of their coming in contact with stones or gravel.

When weeds are heavy, section foremen can greatly improve the appearance of their track and save considerable labor, by bolting a piece of timber to the end of the hand car, allowing it to project far enough out on the side of the track to carry an iron rod with a small steel shovel at its end to mark on the ground the outside line for cutting weeds as the car is pushed ahead on the track. A still better plan is to rig out a thin steel wheel, which offers less resistance to the motion of the car.

Ballast. *Crushed stone* is the best kind of ballast since it makes the most solid foundation, drains the track most thoroughly, does not heave the track in cold weather, does not wash, makes little or no dust, and stands the wear and tear of heavy traffic better than any other kind. There is no doubt that ties last longer in stone ballast than in any other, but it is hard to give exact data as to how much longer.

Furnace slag was extensively used on roads in the eastern part of the country until the adoption of the process of granulating it at the steel mills about ten years ago because of economies effected in the handling of it. However the granulated slag now received from the mills is used to some extent and ranks very close to gravel for general excellence as ballast.

Gravel is easier to procure along a large percentage of roads than crushed stone, makes easier riding track, and is easy to handle; it also permits of track being readily lined and surfaced and ties renewed with little labor.

Burned clay ballast is used in parts of the country where gravel and stone are not available.

Cinders make an effective ballast and are used on account of their cheapness, it being necessary to load them at ash pits, and those not required for filling in connection with new work may be utilized to advantage for this purpose.

Levels. Levels should be taken by engineers and grade stakes set every hundred feet apart indicating

the height to which it is desired to bring the top of the rail. If for any reason it is not possible for the engineers to give grade stakes, as sometimes happens when track is being re-ballasted, the spot board should be used, which very useful and convenient tool will now be described for the benefit of any who may not have had occasion to use it.

Spot board. For use in raising track and ballasting this board may be ten feet long, eight inches wide

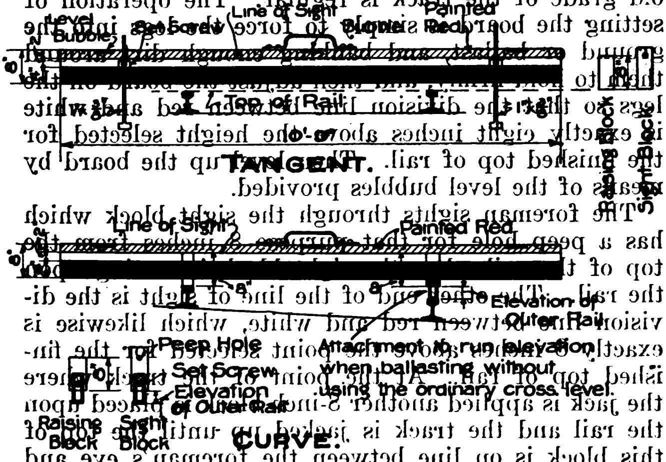


Fig. 21. Spot Board

and about one and a quarter inches thick, constructed of white pine as shown in Fig. 21. One of the legs should be about sixteen inches long and the other three feet, both being adjustable by means of the set screws shown. A convenient coloring for the board is to have the lower half black, then a two-inch white stripe, and a two-inch red one, the line of sight being to the division line between the red and the white stripes,

or two inches below the top of the board. Use an eight-inch raising block so that the top of finished rail will be two inches below the bottom of the board or eight inches below the line of sight.

The use of the spot board permits of taking out all small irregularities in the grade by running from one high spot to another where it is not desired to change the height; or it may be used for making a uniform lift in ballasting such as is often the case when the old grade of the track is regular. The operation of setting the board is simply to force the legs into the ground or ballast, and banking enough dirt around them to hold firmly, and then adjust the board on the legs so that the division line between red and white is exactly eight inches above the height selected for the finished top of rail. Then level up the board by means of the level bubbles provided.

The foreman sights through the sight block which has a peep hole for that purpose 8 inches from the top of the rail when the sight block is resting upon the rail. The other end of the line of sight is the division line between red and white, which likewise is exactly 8 inches above the point selected for the finished top of rail. At the point of the track where the jack is applied another 8-inch block is placed upon the rail and the track is jacked up until the top of this block is on line between the foreman's eye and the division line on the spot board. If the track is straight and there is no super elevation to provide for, both rails are brought up in exactly the same way, or one rail can be raised in this way and the other one leveled to it. If on a curve, there are two ways of providing for the elevation of the outer rail.

First:—Run in one rail or the other by the method described above and use this as a basis in fixing the height of the other rail by means of the cross level.

Second:—Have the spot board set so that the line

of sight is eight inches above the height selected for the "high rail" and when running the "high rail" use the eight-inch blocks just as explained above; but in running the low rail run adjustable slide on both the sight and raising blocks down to increase the height of these by the amount of super-elevation desired, or in other words if you want four inches' elevation run the slide down four inches which makes the block twelve inches high to use on top of the rail instead of eight, so that the low rail will be run in just four inches lower than the high rail where the plain blocks are used without the extension slide. By referring to the lower part of the figure the application and use of the spot board on a curve will be understood. Track with elevation can be run in quite accurately by this method but of course not so accurately as with the cross level, which should be used when giving the final raise and surface.

Cleaning stone ballast with screens. Stone ballast is now generally cleaned on American railroads by shaking it out with ballast forks. During the summer of 1912 experiments were made on the Baltimore & Ohio Railroad with screens for cleaning this type of ballast. The experiments indicate that the use of screens is preferable to the use of ballast forks, both on account of better work and lower cost. The type of screen and the method and cost of using it for cleaning stone ballast, were described by Mr. W. I. Trench, Division Engineer of the Baltimore & Ohio Railroad, in an appendix to the report of the Committee on Ballast of the American Railway Engineering Association. The information here given is taken from Mr. Trench's description as published in the Bulletin of the Association for February, 1913.

In approaching the problem of cleaning ballast by means of screens, it was recognized that the present methods involved one of the most expensive and

tedious operations occurring in railway maintenance and that for this reason the periodical cleanings are often deferred much longer than good practice would seem to demand. It was felt that if a screen could be designed which would make a proper separation of stone and dirt and at the same time dispose of these two materials in a way to avoid further handling, with a single cast of the shovel instead of the repeated sifting motion and the further shoveling of the dirt in its disposal as required by the fork, an enormous saving could be made.

It was believed that to be practicable this screen must be as cheap as was commensurate with durability, easily portable, and so related in position to the track when in use as to make its removal unnecessary on the passage of trains. Its operation must be progressive along the track and complete, working toward the dirty ballast and leaving the clean ballast behind it in such shape as to require no further handling. Its capacity must be limited only by the speed with which the laborers can handle the shovel and it must be susceptible to use by a gang, so arranged that the work of every man is continuous and unchanging and so proportioned that no man's work is dependent on the progress made by another; that is, there should be no halts. It is believed that these results have been secured in the screen to be described and that its use, by a properly organized gang, will result in such a saving as to make the further general use of the fork method improbable.

Experiments on the Baltimore & Ohio Railroad were made on a portion of its double track line, and it was found that the most efficient gang for this condition was one of twelve men equipped with three screens. There is a screen for each berm and one for the center ditch. The construction of all three is identical, there being interchangeable legs for use on the berm,

and in the center ditch. The legs for use on the berm are so designed that the screen rides on the ends of the ties outside the rail at such a distance from the track as not to interfere with traffic, and at the same time deposits the cleaned stone on the berm in final position. It stands at such an elevation that the dirt is deposited directly into a wheelbarrow standing on subgrade. The legs for use in the center ditch are designed to ride on the cleaned subgrade as the screen is slid along and are of such a height that the dirt is deposited in a handbarrow, which is placed beneath the screen, and the clean stone is left in the center ditch in final position. The upper end of the screen is carried on supports which are readily adjustable in height to accommodate it for use in the center ditch or on the berm in either cut or fill. When in use in the center ditch, the screen is laid flat upon the ground on the passage of trains and lies wholly below the top of rail.

A short description of the structural details will be made so that a better understanding will be had of the method of operation to follow. The screen frame is constructed of standard 2-in. x 3-in. x 1¼-in. angle iron set up so that the short leg turns out, the long leg forming the vertical sides of the screen. The screen proper is formed of ¼-in. rods, crimped together, giving a mesh ¾ in. x 8 ins.. It was found with this mesh and with the screen inclined at 45° that the separation of stone and dirt was perfect even in damp weather, and this cannot always be said of the results secured from forks. These crimped rods are set in a rectangular steel frame made of 1-in. x ½-in. x ⅛-in. channel iron, and this frame is bolted inside the main frame so that the screen proper can be readily detached, as a whole, and sent to the shop for repairs. The entire screen is backed with a galvanized iron slide which is so formed that it gathers

the dirt which has come through any part of the screen and deposits it in a receptacle set beneath by means of a spout. The spout is really a hinged door suspended at its outer end by a chain and convenient fastening so that its height can be regulated, and when the receptacle is removed for emptying, can be closed. With this door closed the screen will hold about one wheelbarrow load of dirt, so that the operation of the screen is not stopped while dirt is being dumped. At the top of the screen is a hood which forms a deflector for the ballast thrown over the top, the method of operation in this case being to slide the screen backwards from the cleaned ballast towards the uncleaned ballast, the latter being thrown over the top and being left in clean condition at the bottom. This hood when screen is in use on the berm is thrown back and forms the top against which ballast is thrown when in this position. The screen constructed as indicated is practically indestructible and will support the weight of a man without impression.

For use with each screen is provided a galvanized iron handbarrow which is so formed that it fits exactly upon the horizontal legs when in use on the berm, being so placed after a sufficient quantity of cleaned ballast has been allowed to fall outside the rail, that the remainder is caught in the handbarrow and drawn across the rail to be deposited in the cribs. When in use in the center ditch, the handbarrow is placed beneath to catch the dirt.

The cross-section of the finished work is shown in Fig. 22. It will be noted that the cribs are cleaned to the bottom of the ties, the center ditch 18 ins. below the top of rail and the berm 24 ins. below the top of rail at the end of tie and sloping to 3 ft. below top of rail at back of side ditch. Every 50 ft. one crib is cleaned to the bottom of the center ditch on one end and to the top of subgrade on the other, forming an

outlet for water collected in the center ditch. This arrangement gives an absolutely dry and stable roadbed. The dirt from the ballast, or so much of it as is required, is dressed upon the subgrade outside the ballast line, and in addition to giving a neat black appearance and a pleasing contrast to the white stone ballast, serves to keep down weeds very effectually. What is not required for this purpose is used to widen embankment along the line.

As stated above for double track work, three screens are used. When tracks are on fill on both sides, dirt from each side screen is disposed of on its own side of the embankment, and dirt from the center ditch is dumped directly from handbarrow over bank on side

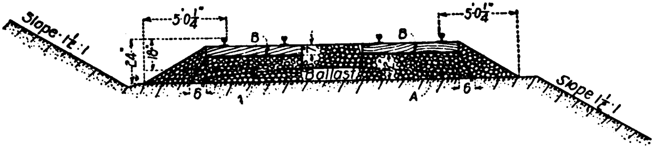


Fig. 22. Roadbed Section for Cut and Fill, B. & O. R. R.

most desirable. When one side is on fill and other side in cut, wheelbarrow loads of dirt are wheeled or carried bodily from cut side to fill side. When it is necessary to carry dirt across tracks, care is used to keep the screen on the side from which it is carried in an advanced position, with reference to the other screens, so that dirt will be carried over uncleaned roadbed and not over that which has been cleaned. It will be seen that dirt carried to the fill on other side of tracks from the center screen passes over dirty ballast before the arrival of the screen to the right, and likewise, dirt from the screen to the left passes over the tracks before the arrival of either of the other two screens, the screens in this case traveling from right to left. When tracks are in cut, on both sides, wheel-

barrow loads are wheeled out to the nearest end of cut, the handbarrow from the screen in the center ditch being dumped into a wheelbarrow or shoveled directly from pan to barrow standing across one rail, dirt from side screens being poured from screens directly into wheelbarrow. It is found that dirt can be wheeled out of a cut for a distance of 800 ft. to 1,000 ft. at less expense than would be the case if thrown upon the ground and loaded again upon a work train on a busy railroad.

"The following gang organization is adhered to: For the operation of three screens as indicated under ordinary circumstances, twelve men are sufficient; with long hauls of dirt, more men to be added for wheelbarrow work, so screen gang will be kept going. Of the twelve men, two shovel from each side of berm onto their respective screens, two from the center ditch onto the center screen, and one man in center of each track shoveling from the cribs onto the screen most available; one man with pick advances ahead of shovelers to loosen hardened ballast before their arrival. These are dispensed with if ballast is loosened by means of a plow attached to work engine. Long stretches of ballast can be loosened in this way in a short time by work engine; enough to keep gang going several days. The remaining three men are sufficient usually to handle wheelbarrows in disposal of dirt, dress dirt down on berm and fork a uniform ballast line, although if hand laid ballast line is required, more men would be necessary. By careful handling of this gang, ballast and dirt are disposed of at one operation in their final position and no further attention is necessary. In most cases it is found that the cleaning of ballast so reduces its volume that additional stone is necessary. In this case the disposition of the stone from the screens is so handled that the berms and center ditch are filled out completely,

and any deficiency occurs between the rails where additional stone can be most conveniently distributed from Rodger ballast cars without further handling. The gang of twelve men costs per day: Foreman, $2.40; 11 laborers at $1.60, $17.60; total, $20.

"A gang equipped and organized as above will cover 165 ft. of double track per day of 10 hours, making the cost per mile of double track, $640. This, of course, includes cleaning ballast, dressing ballast and disposal of dirt complete. Single track work would cost considerably less than half this amount, as there would be no center ditch to contend with. The ballast really handled in this test was considerably more than the cross-section, shown in Fig. 22, would indicate, as before cleaning the ballast was piled above rail in center ditch and rounded high on berm. An average of 227 wheelbarrow loads of dirt were removed per 100 ft. of double track cleaned.

"For comparison with the fork method, the identical gang used above was tried with forks and advanced but 72 ft. per day. This also included the dressing complete and disposal of dirt, it being necessary to shovel the latter in wheel and handbarrows. This shows a cost per mile of double track of $1466."

We see various figures given from time to time on the cost of cleaning ballast per mile. Some of them are very much less than the above, and we can only believe that this is occasioned by omitting to include the disposal of dirt and dressing road complete, or on account of cleaning to a less depth in track than indicated in Fig. 22, or perhaps a less thorough separation of stone and dirt. In many cases, a raise is given the track and ballast is put under without cleaning. In the above test, no raise was made.

"This screen weighs about 325 lbs., and can be easily propelled along the track by the two shovelers at work at the respective screens. With the material

used in them with careful handling and painting, they should last for years. The trial lot of three made with handbarrows complete by a Baltimore firm cost $45 each.''

Both sides of the track should be raised and tamped at the same time when ballasting or taking out sags; otherwise, if first one side is raised and tamped and the other side afterwards it will have a tendency to throw the track out of line, and there will be a place under the side that was first raised which is not tamped. Do not tamp in the center of the track, as this produces center-bound track and will result in broken ties.

High places. Short high points in the track to be ballasted should not be raised at all if they are higher than the surfaced track, but should be let down, if this requires less labor than to surface up the track to the high point.

Uniform tamping. The secret of putting up good smooth track that will remain so for a long time lies in having your men well organized, and in getting them to work as nearly alike as possible. Uniformity in the work is everything. Where sand or gravel is used, a first-class track can be ballasted by having the men put the material to place under all the ties with the shovel blade, tamping only the joint ties, and picking up the low places after some trains have passed over it.

A tie should be tamped throughout, so as to furnish as solid a bearing as possible, but care should be taken that it does not become centerbound, or, in other words, the middle of the tie so supported as to cause the track to rock. On double track roads it will assist the general condition of the track to tamp the leaving side of the tie harder than and after the other, thus forming a wedge and arresting any slight forward movement.

Mechanical tamping. There are several electric and pneumatic tamping machines on the market. One of these is called the "Imperial pneumatic tamping machine" and has materially reduced the cost of track ballast and maintenance. These machines are operated in pairs, one on each side of the tie, the operation of the tool being a rapid hammer action on the tamping bar, which in turn compacts the ballast and forces it down and under the tie, each tie being tamped a distance of about 16 to 18 in. either side of the rail. Observations made on a railroad where new track was being raised from 2 to 3 in. on stone ballast showed an average of 240 ties tamped per nine hour day, at a total cost of 2 cents per tie. These machines operate very conveniently in cramped quarters, such as switches, frogs and crossovers, where hand tamping is difficult and sometimes almost impossible to do well.

For operating these tampers an air compressor is necessary, and is generally built in the style of a gasoline motor; consisting of a vertical air compressor mounted on a hand car with reservoir cooling system direct connected to a gasoline motor, accompanied by a suitable air receiver and piping. These compressor cars are self-propelled and capable of transporting the section gang to and from its work. The tamping machines are economical in air consumption and may possibly be operated from switch and signal service air lines without interfering with the operation of signals, etc. They handle stone, cinder or other ballast with equal effectiveness.

The New York Central Railroad made some experiments in 1914 with tamping machines, where ties were being spaced and the track lifted from 2 to 4 in. by the action of the machines. One of the tests consisted of spacing ties under new rails, raising the track on stone and doing the work of the section gang. Another test was for regular section work, spacing

ties and surfacing the track. Still another test was done by a main line section gang using the mechanical tamping outfit after the track had been raised 12 in. on stone by a special gang. The time necessary for the work increased with the thickness of the layer of ballast. A lift of from 2 to 4 in. required 2 min. for two machines. Ordinarily it required 2 min. for a tie.

The final conclusions from the tests were as follows:—

(1) Mechanical tampers can raise track; (2) Less settling was observed when the tampers were used than by hand work; (3) The settling of track was more uniform; (4) Machine tamped track is more permanent. The only difficulty encountered in using the machines was the breaking of their parts.

In air operated tampers the work was satisfactorily done at distances of 600 ft. and also at 50 ft., the cost of the apparatus being reasonable. One complete unit of three tampers, 600 ft. of hose and compressor mounted on a car cost about $1800.

A self-propelled compressor car was equipped with clutch, sprocket and chain for driving one pair of wheels, and the car could be moved at 12 to 15 miles per hour. It had a deck 9 ft. by 5 ft. 5 in. and could easily hold twelve men; weighed 2180 lbs., gasoline and water 145 lbs., and the hose and tampers 170 lbs.; total weight 2495 lbs.

In the first test with an average of 26 ties per hour a raise of from 2 to 4 in. was accomplished by machine work. One mile of track done in 13½ days, including 3200 ties, cost $86.40, compared with $282.60 by hand.

In the second test the hand work required 9 days for a mile of track and cost $550.80, while the machine did it in 13 days at a cost of $417.69.

The general result of the tests was that the machines would accomplish the same work at considerably

lower cost than the hand work and with more permanent results. "Two men equipped with a pneumatic tamper can tamp more ties than eight or ten men using picks and bars."

A stability test was made on a stretch of track 1600 ft. long across the Hackensack Meadows in 1913. "Half of the test section was tamped by the usual hand methods and half by the pneumatic tamper. At this point, owing to yielding foundation, it is difficult to maintain the track in proper surface. After six months of service under heavy traffic the maximum settlement of hand tamped ties was .116 ft. and of the machine tamped .063. The corresponding minimum figures were .018 and .004, and the figures for average settlement were .067 for hand and .033 for machine tamped ties respectively. A year's cost record for one pneumatic tamper showed an average cost per tie tamped of $0.026."

The proper size of tamping face for different kinds of ballast. Mr. H. L. Hicks states that in crushed stone ballast which is 2″ or more in size, a bar with a face 3″ by 5/8″ gives the best satisfaction; and he recommends a tamping face of 3″ by 7/8″ for smaller stone or gravel, and a tamping face of 3″ by 1 1/8″ for tamping sand, dirt, or cinders.

A day's work. A little judgment will enable any foreman to so arrange the work that, when he and his men finish in the evening the track where they were working will be in good shape and will remain safe for several days if necessary. It is very important that all track should be filled in and dressed up as fast as it is surfaced in order to preserve a good line on the rails. Track which is not filled between the ties will not stay in line.

Ballast in cuts. Only the cleanest of gravel ballast should be unloaded in cuts for ballast. Where it is necessary (in order to get rid of them in the pit) to

haul out on the track, together with the gravel, large stones, grass, sods, etc., they should always be dumped on an embankment where they will assist in strengthening the fill.

Have the track ready. When ballasting track or raising it to surface, the foreman should so arrange his work that the track can at all times be readily adjusted for the safe passage of trains. He should make a "run-off" at the last rail of the track raised, and the outer ends of ties at least should be tamped up before a train is allowed to pass over it. The length of the "run-off" should be in proportion to the height to which the track is raised. Never make a "run-off" too short; it is better to flag a train and hold it until you are ready than to risk surface-bending the rails, or wrecking the train. Foremen ballasting track should always protect themselves against all trains by keeping a flag out against them.

High raising. When track is raised more than six inches high in order to put ballast under it out of a face the foremen employed on the work should be thoroughly competent and reliable. One foreman should work the larger part of the surfacing gang, and with them lift the track, tamp the ties, and do a part of the filling, leaving the track behind him with a true surface, level, and in good line. Working some distance behind the first gang another foreman with a smaller crew of men should do the finishing work. He should be several days behind the first gang, so that any poor tamping or weak places may be fully developed. He should carry, besides his other tools, a full set of tamping bars, and should raise up all depressions in the surface of the track made by trains which passed over it after the first gang left it. Every piece of track taken up to surface by the second gang, should be tamped solid with tamping bars or picks.

The rails should be lined true, the balance of the

gravel filled in, and the sides and center of the track dressed up, all surplus ballast being moved to points along the line where it is needed to make the shoulder of uniform width.

Gravel for one mile of track. Allowing an average of 36 ft. for each car length, including the space between the cars, one hundred and fifty cars of gravel will reach over one mile of track. If this amount of gravel be unloaded by hand, or plowed off from the cars, which is a better way, and if the trains average about eight yards of gravel to the car, there will be gravel ballast deposited along the track equal to six inches in thickness, twelve feet wide on top, and twelve feet six inches wide at the bottom, for the entire length of one mile of track. Deduct from the above amount of gravel about one-half for filling between the track ties and for dressing the center of the track after it has been surfaced up, and there is still left a balance of about three inches in thickness to be put under the bottoms of the track ties.

It is now customary for large roads to use coal cars for handling ballast, averaging about 35 cubic yds. per car, with over all length of 40 ft.

Where the sub-grade is well drained and solid, a first-class track can be made by ballasting with half a cubic yard per lineal foot of track. The embankment should not be less than fourteen feet wide on top, and should be made sixteen feet wide, if possible, before putting on the gravel, to prevent the ballast from being wasted by running down the bank.

Level track in yards. The tracks in all yards should be surfaced level throughout their entire length, and all tracks running parallel with each other should be of the same height when it is possible to have them so. When tracks have once been put to a uniformly level surface, no part of them should be raised again higher than the rest of the yard un-

less it is intended to raise the level of the whole yard.

Many inexperienced foremen in charge of yards think it is necessary every time they repair track to surface it a little higher than it was before, which is a harmful and senseless policy and should not be tolerated.

How to level yard tracks. A simple method by which to get tracks that run parallel to each other to the same height is as follows:

First, put up the main track properly, then use a straight edge from the nearest rail of the adjoining track in order to raise it to a level with the main track. You can then move to a point several rails ahead on the main track and repeat the operation. After this you can raise the track on the siding between the two points which you have made level with the main track.

Rule:—Run the level and a straight edge on the top of two or three stakes located parallel with the track to be leveled, and do the same at a place some distance from that point. Then sight over the tops of the stakes at both points, and have a man drive stakes between the two places where you have leveled, until the stakes which he has driven are at the same height as those you have leveled with the level and straight edge. The top level of the stakes will be the level of the track rails. In important yards the company's engineers generally give level stakes for all tracks.

Gravel pits. A few words about the gravel pit will not be out of place in this book.

On roads where stone, or other satisfactory ballast is scarce, or cannot be procured, a gravel pit along the line is very desirable. There are very few roads that cannot find at least one or two gravel pits along a division.

After the gravel pit has been purchased, and when the work of removing material is about to commence,

the foreman in charge should thoroughly examine the lay of the land and decide how his track must be laid to get the deepest face of gravel to work on. Of course, at the same time, the best location for the track must be arranged for the accommodation of trains, and this should be done with a view to future improvements.

The track should always be longer than the face of the gravel in the pit, so that one, ten, or any number of cars can be loaded without danger of spoiling the line of the pit face. This is very important, because where a short track is put in on account of a handy place to put in the switch, or for the reason that there is not much gravel needed at that time, the face of the pit contracts and becomes so short that the loading place is like a sink hole in the ground, and it soon becomes difficult for an engine to pull out of the pit more than two or three cars at a time, making necessary six or seven switches to do what could be done by one with a good track. Besides this there are other reasons why a short track should not be used. The men loading the gravel keep lining the track over as the bank recedes and there is soon a heavy curve in the track which follows around the edge of the excavation, so that it is only a short time until the track has to be torn up and the work all done over again. At this time the loss occasioned by gouging a hole in the bank is discovered. If the track is then laid along the face of the pit, cars can be loaded only at either end of the pit, and there is loss of time from placing them, switching, etc., and perhaps the two ends of the pit next the track are not long enough together to allow a full train of gravel to be loaded at once, but there is no help for it except to work at the ends, until the gravel can be reached all along the track.

Another argument in favor of a longer track is that

the face of the gravel can be increased in depth by lowering the track.

Foremen in charge of loading gravel should see that the men load in one place until there is a space on that side of the track at least two or three feet lower than the ties and wide enough to let the track into it. It should then be lined over, enabling the men to load on each side of the cars. Every foot that the face of gravel can be deepened makes the cost of loading it less, and reduces the proportion of top soil which mixes with the gravel.

A steam shovel or locomotive crane, with a sufficient number of coal or ballast cars, is the best equipment to use for economically getting out gravel from the pit.

Ballast gang. A gang of forty men organized as follows may be used to advantage in ballasting track.

	Number
Foreman	1
Assistant Foreman, sighting track	1
Assistant Foreman, track tampers	1
Flagmen, to furnish protection in either direction	2
Laborers, digging jack holes	1 or 2
Laborers, operating jacks	4
Laborers, tamping at jacks	4
Laborers, holding ties tight to rail	2
Laborers, driving spikes home	2
Laborers, back tampers	16
Laborers, partially filling and dressing track	4
Water carrier, supplying force with drinking water	1
Total	40

NOTE: When not raising track on account of interference with traffic or otherwise, the time is to be employed in finishing the dressing of track and lining the ballast; also in cleaning out and preparing track ahead for ballast.

Depth of ballast. The height to which track is to be raised should be fixed by the engineers. The fol-

lowing figure represents a good cross section for single track roadbed together with the diagrams for broken stone and gravel ballast.

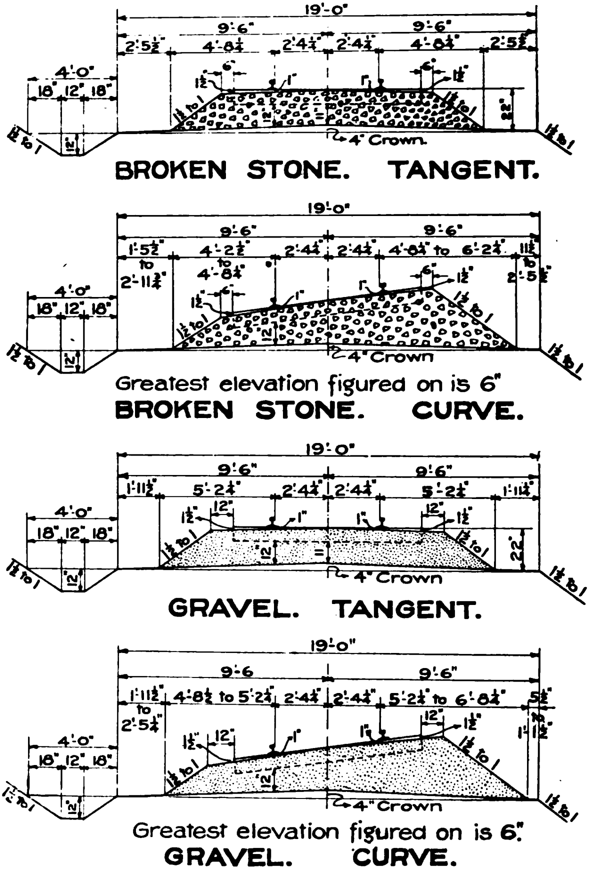


Fig. 23. Roadbed Sections

Tamping. In gravel, granulated slag and cinder ballast, tamping picks should be used only at joint ties, shovels at all others. With broken stone ballast all ties should be tamped with picks from the ends to a point twelve inches inside the rail, centers of ties to be lightly filled in by use of ballast forks. After the first raising about one week should elapse for ties to secure a good bearing and then the final surface should be given. In resurfacing joint ties they should be tamped hard on the joint end, easing off towards the center.

Tools and methods for tamping recommended by the American Railway Engineering Association:—

Earth or clay ballast: Tools: Shovel equipped with iron cuff or handle for tamping; broad pointed tamping bars.

Method: Tamp each tie from 18 inches inside of the rail to end of tie with handle of shovel or tamping bar. If possible, tamp the end of the tie outside of rail first and let train pass over before tamping inside of rail; give special attention to tamping under the rail; tamp center of ties loosely with the blade of the shovel; the dirt or clay between the ties should be placed in layers and firmly packed with feet or otherwise, so that it will quickly shed the water; the earth should not be banked above the bottom of the ends of the ties; the filling between the ties should not touch the rail and should be as high as, or higher than, the top of the ties in the middle of the track.

Cinder ballast (railroad product): Tools: Shovel, tamping bar or tamping pick.

Method: Same as for gravel.

Burnt clay ballast: Tools: Shovel only in soft material. When burnt very hard, tamping pick or bar should be used.

Method: Tamp 15 inches inside of rail to end of tie, tamping end of tie first, letting train pass before

tamping inside of rail; tamp center loosely; tamp well between the ties; dress ballast same as for earth or cinders.

Broken stone or furnace slag: Tools: Shovel, tamping pick, stone fork.

Method: Tamp 15 inches inside of rail to end of tie; if possible tamp the end of the tie outside of rail first and allow train to pass over before tamping inside of rail; tamp well under the rail; tamp well under ties from end of same; do not tamp center of tie; fill in between ties to height of top of tie; bank ballast into shoulder about the end of the ties level with top of tie.

Chats, gravel or chert ballast: Tools: Shovel, tamping pick or tamping bar. For light traffic, shovel tamping is sufficient. For heavy traffic, the tamping pick or tamping bar should be used. The tamping bar is recommended instead of the tamping pick for ordinary practice.

Method: Tamp solid from a point 15 inches inside of rail to the end of the tie; if possible, tamp the end of the tie outside of the rail first and allow train to pass over before tamping inside of rail; care should be taken not to disturb the old bed. Tie should be tamped solidly from the end, using the pick or tamping bar. After train has passed, the center of the tie should be loosely tamped with the blade of the shovel; dress same as stone ballast.

General: When not surfacing out of face, as in the case of picking up low joints or other low places, the general level of the track should not be disturbed. Where the rails are out of level, but where the difference in elevation is not excessive and is uniform over long stretches of track, a difference in elevation between the two rails of $3/8$ inch may be permitted to continue until such time as the track would ordinarily be surfaced out of face.

VIII

RENEWAL OF RAILS

The weight of steel rails in main tracks on railroads in this country varies from sixty pounds to one hundred and forty pounds per yard and although there may be some of the iron rail of lighter weights in use it is fast becoming obsolete. The introduction of heavier power and increased wheel loads on all classes of equipment in recent years has also increased the necessity for more substantial track and this has been secured by the increased use of stone ballast, ties of better grade, and heavier rail. The weight of rail varies with the requirements of the traffic of the particular lines as to speed of trains, weight of cars and engines, density of traffic, or a combination of these. The Baldwin Locomotive Works rule is that each 10 lbs. weight per yard of ordinary steel rail, properly supported by cross ties, is capable of sustaining a safe load per wheel of 2240 lbs. This rule calls for a rail heavier than the average used on roads possessing very large locomotives. On the other hand rail calculated by this rule would not be economical on roads using small contractors' locomotives; a larger rail being required.

The gross tons of rails required for one mile of track is exactly found by multiplying the weights per yard by 11 and dividing by 7. An allowance of about 2% should be made for cutting.

As a general thing railroads that up to six or eight

years ago had 80, 85 and 90 lb. rails for main track service, are now supplanting these very rapidly with 100 lb., 105 lb., 125 lb., and as high as 135 lb. metal. The American Railway Engineering Association has adopted as standards for use sections of rail from 90 lbs. to 140 lbs., varying from each other by 10 lbs.

The roads are now buying new rail only of the heaviest types and sections suitable for use on their most important and high speed tracks, the rails released by the installation of these being sorted out and the best of them used for so called "main track patching"; the next grade, or rails not required for such use, are put on slow speed freight tracks or main track of branch lines, where traffic is lighter and schedules slower. Still another class of steel is used in side tracks and yards. Those rails not suitable for any of the above purposes are sold for scrap.

Nothing improves the physical condition and riding qualities of a piece of track more than new rail. It is one of the principal items of expense on maintenance and should have the attention that its importance deserves as to care in laying and surfacing and afterwards the tightening of bolts in order that the maximum life may be secured. If rail be not kept in good surface after having been laid it soon becomes battered at the joints and kinked, the condition of the ballast of course having a great deal to do with the standard of excellence of line and surface that can be maintained.

Life of steel rail. The life of rail in main tracks varies from one to fifteen years or more, depending on the quality, the traffic and the location, whether on tangent or curve.

On tangent track the wear of the two rails is ordinarily the same, but on curve track the wear on one rail is generally more than on the other. If there are

more slow speed trains than high speed the greater part of the load will be supported by the inside or low rail of the curve, and the low rail will be worn thin, whereas if there is an excess of high speed trains the outside or high rail in addition to becoming top or surface worn becomes flange or side worn.

Laying new rail must be done with as little interference to traffic as possible, and to accomplish it the time of the day when there is the longest period between the passage of trains should be selected. The new rails should be set up along the ends of the ties opposite where they are to go but without being coupled together, otherwise there is liability of spoiling the expansion. It is sometimes permissible to slide the rail in by long strings coupled together when relaying on tangents, but when relaying on curves rails should always be laid one at a time. The rail gang can utilize all the time to advantage, and when not engaged in actually changing rails on account of trains that are due the time can be profitably spent in uncoupling old rails or placing rails for application when opportunity offers. The adzing work should be done as far as possible, and as many spikes and bolts removed or started in advance of the time when the track can be secured as can be safely spared. Full preparation should be made and everything possible attended to before the integrity of the track is disturbed, so that when the track is opened the work can be rushed in every possible way.

Rail laying gang. When relaying rail a gang of forty men may be employed to advantage, organized as follows:

Force required for laying single rail.

	Number of men
Foreman	1
Assistant Foremen	2

	Number of men
Flagmen—To furnish protection in either direction	2
Spike Pullers—Pull all spikes on one side to permit old rail to be removed	4
Rail Removers—Carry lining bars and throw out old rail	2
Adzers—Do all necessary adzing and plug old spike holes	6
Tongmen—Place new rail in position	8
Bolters—Apply new joints and tighten bolts	8
Shimmen—Clean seat for new rail	1
Carry shim box with thermometer and place proper shim for expansion	1
Spikers—Spike new rail in position	4
Water Carrier—Supplies force with drinking water	1
Total	40

For relaying both rails at the same time the above force should be duplicated with the exception of the flagmen.

When laying two lines of rail one line should not be laid until the first has been laid far enough ahead to furnish line side for spiking.

Gaging. When the proper gage can be maintained draw spikes on the inside of rail; when rail wear or change in design of rail affects the gage, pull spikes on the inside of one rail and the outside of the other, and where necessary pull the two inside lines and one outside line. Proper gage should be made as the new rail is laid.

Expansion. The usual length of rails rolled now is 33 ft., and to secure the proper space for expansion or contraction a shim box with partitions to hold shims of the different sizes required in separate compartments should always be provided. Provision should also be made for carrying a thermometer in such a way that it will not easily be broken; the thermometer should have a tin or metal back and the temperature should be taken on the rail. Shims should be used of the proper size to give the space re-

quired for the different temperatures as shown in the following table.

Allowance for expansion—33′ rails.

Temperature (Fahrenheit)	Allowance.
—20° to 0°	5/16 inch
0° to 25°	1/4 "
25° to 50°	3/16 "
50° to 75°	1/8 "
75° to 100°	1/16 "

At temperatures over 100°, rail should be laid close without bumping.

To maintain the proper expansion the ties should be spaced and slot spikes and rail anchors applied as soon as possible to avoid their becoming distorted by creeping rail. Various devices for preventing the creeping of rail are described in Chapter IX.

Closing up for trains. The force employed as indicated for the relaying gang will keep the work going continuously, or until necessary to close up the track to let trains over. When closing up, make a good substantial job, cutting old rails in preference to the new ones. The use of switch points for this purpose, which have been the cause of many accidents in the past, should not be allowed at all. If the rails being laid are the same length as the ones removed it may be necessary to cut a very short piece from a full length rail to make closure. It is therefore a good plan to carry two pieces of rail about 10 ft. long, equipped with compromise joints if necessary, which when laid in will "carry by" so that a good sized piece can be cut from a full rail to close up properly.

Rail sections. The following tables show the sizes of rails of different weights per yard and certain information relative to the adoption of the different types is given.

Table, Weight of Rails.

Wgt. per yard, Lbs.	Rail per mile, in Tons of 2240 lbs.	Miles of single track, per 1000 gross tons of rails, (No allowance)	Feet of single track per ton of rails
100	157.14 = 157 tons, 320 lbs.	6.36	33.60
95	149.29 = 149 " 640 "	6.70	35.37
90	141.43 = 141 " 960 "	7.07	37.33
85	133.57 = 133 " 1280 "	7.49	39.53
80	125.71 = 125 " 1600 "	7.95	42.00
77½	121.79 = 121 " 1760 "	8.21	43.35
75	117.86 = 117 " 1920 "	8.48	44.80
70	110.00 = 110 " 000 "	9.09	48.00
68	106.86 = 106 " 1920 "	9.36	49.41
67	105.29 = 105 " 640 "	9.50	50.15
65	102.14 = 102 " 320 "	9.79	51.69
60	94.29 = 94 " 640 "	10.61	56.00
58	91.14 = 91 " 320 "	10.97	57.94
56	88.00 = 88 " 000 "	11.36	60.00
55	86.43 = 86 " 960 "	11.57	61.09
50	78.57 = 78 " 1280 "	12.73	67.20
45	70.71 = 70 " 1600 "	14.14	74.67
40	62.86 = 62 " 1920 "	15.91	84.00
35	55.00 = 55 " 000 "	18.18	96.00
30	47.14 = 47 " 320 "	21.21	112.00
25	39.29 = 39 " 640 "	25.45	134.39
20	31.43 = 31 " 960 "	31.81	168.00
16	25.14 = 25 " 320 "	39.77	210.00
12	18.86 = 18 " 1920 "	53.03	280.00
8	12.57 = 12 " 1280 "	79.55	420.00

Rail sections used on steam roads.

(From "Steel Rails, Their History, Properties, Strength and Manufacture," by William H. Sellew. By permission of D. Van Nostrand Co.)

The early steel rails were naturally made to the existing iron pattern. These were generally pear-headed in order to prevent the side of the head from breaking down and were not adapted to fishing as the design prevented the joint from supporting the head.

The adoption of an improved section was very slow,

and, as late as 1881, 119 patterns of steel rails of 27 different weights per yard were regularly manufactured, and 180 older patterns were still in use, making a total of nearly 300 different patterns. This great variety of sections in use required the mills to keep a large number of different rolls in stock, and finally, to standardize the design of the rail, the A. S. C. E. section, Fig. 24-A, was presented to the society on August 2, 1893. These sections met with favor, and were adopted by many railroads, so that in a few years about two-thirds of the output of the rail mills conformed to this design.

While the A. S. C. E. section was apparently well adapted for the light-weight rails of 65 pounds and 75 pounds in use when it was designed, the increase in weight on railway wheels soon necessitated a heavier rail, and the manufacturers of rails claimed that it was difficult to make these heavier rails of the A. S. C. E. section due to the thin edge of the base.

Realizing the importance of the question, the American Railway Assn. appointed a special committee on Standard Rail and Wheel Sections. This committee, through a subcommittee on which the manufacturers were represented, devoted a large amount of time and attention to the matter of sections and specifications for steel rails and presented a preliminary report to the association, Oct. 1, 1907.

Accompanying the report of the committee were two series of proposed standard sections: Series "A" designed to meet the requirements of those who advocate a rail with thin head and a high moment of inertia, and series "B" to meet the requirements of those who think that there should be a narrow, deep head, with the moment of inertia a secondary matter. See Fig. 24, B and C.

On June 5, 1907, a joint committee of the Penna. R. R. system—Mechanical and Civil Engineers east

and west of Pittsburgh—was appointed to study the rail question, and on Sept. 20, 1907, their labors resulted in designs for 85-lb. and 100-lb. rail sections (see 24D).

This section, known as the "P. S." section, is a step farther away from the "A" section. It has a still heavier head, a narrower base, and thicker flanges than the "B" section. The radius of the web is smaller, thus producing more of a buttress where the head and web join.

The experience of the Pennsylvania system seems to be that with their heavy wheel loads and dense traffic more rails fail from crushing and disintegration of the head, apparently due to the pounding of the traffic, than from any other one cause, and accordingly in this section the maximum effort has been made to strengthen the rail in its weakest point.

The sections given in Fig. 24, B, C, and D of the rails used at the present time show the modifications which have been made to meet the criticism of the manufacturers in regard to the faults in the design of the heavier A. S. C. E. sections.

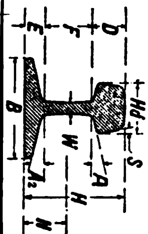
These thick base sections, adopted after the studies of 1907, cool with less curvature than the former thin base types and require less cold straightening. The straightening or gagging tends to develop injurious strains in the base, and there appears to be a fewer number of base failures in the new sections as compared with the A. S. C. E. design.

To still further reduce the failures in the base of the rail, Dr. P. H. Dudley has designed a section for use on the New York Central in which the radius of the fillet between the base and the web is increased to one inch.

Laying rail under heavy traffic. Mr. W. F. Rench of the P. R. R. recently published the following excellent notes in the Ry. Age Gazette:

STANDARD TEE RAIL SECTIONS

(by permission of Lefax, Phila.)



H—height
B—base
Hd—head
W—web.
D—depth of head
F—fish
E—depth of base
A—head angle
A₂—base angle
S—slope of head
N—center of web

All dimensions in inches.

Type	Wt. Yd.	Ill. St. Old No.	Ill.St.,Carn. T.C.I.	Cambria	P. S. Co.	Lack. St. Co	Colo. F&ICo	H	B	Hd	W	D	F	E	A	A_2	S	N
A.R.A.-A.	100	10020	10020	565	163	10031		6	5 1/2	2 3/4	9/16	1 9/16	3 3/8	1 1/16	4 to 1	4 to 1	1/16 to 1	2 3/4
"	90	9020	9020	563	170	9031	902	5 5/8	5 1/8	2 9/16	9/16	1 15/32	3 5/32	1	"	"	"	2 37/64
"	80	8020	8020	566	169	8031		5 1/8	4 5/8	2 1/2	33/64	1 7/16	2 23/32	31/32		"	"	2 21/64
"	70	7020	7020	567				4 3/4	4 1/4	2 3/8	1/2	1 11/32	2 1/2	29/32	"	"	"	2 5/32
"	60	6020	6020	568				4 1/2	4	2 1/4	15/32	1 15/64	2 29/64	13/16	"	"	"	2 6/128
A.R.A.-B.	100	10030	10030	564	161	10032	1002	5 11/64	5 9/64	2 21/32	9/16	1 45/64	2 53/64	1 5/64	13°	13°	3°	2 66/128
"	90	9030	9030	561	162	9032	905	5 17/64	4 49/64	2 9/16	9/16	1 39/64	2 5/8	1 1/32	"	"	"	2 11/32
"	80	8030	8030	569	171	8032		4 15/16	4 7/16	2 7/16	35/64	1 15/32	2 15/32	1	"	"	"	2 13/64
"	70	7030	7030	570	174			4 39/64	4 3/64	2 3/8	33/64	1 23/64	2 17/64	59/64	"	"	"	2 7/128
"	60	6030	6030	571				4 3/16	3 11/16	2 1/8	31/64	1 1/4	2 1/16	7/8	"	"	"	1 29/32
A.R.E.A.	90							5 5/8	5 1/8	2 9/16	9/16	1 15/32	3 5/32	1	4 to 1	4 to 1	1 to 16	2 35/64
"	100							6	5 3/8	2 11/16	9/16	1 21/32	3 9/32	1 1/16	"	"	"	2 3/4
"	110							6 1/4	5 1/2	2 25/32	19/32	1 23/32	3 13/32	1 1/8	"	"	"	2 53/64
"	120							6 1/2	5 3/4	2 7/8	5/8	1 25/32	3 17/32	1 3/16	"	"	"	2 59/64
"	130							6 3/4	6	2 15/16	21/32	1 27/32	3 11/16	1 7/32	"	"	"	3 1/32
"	140							7	6 1/4	3	11/16	1 29/32	3 27/32	1 1/4	"	"	"	3 9/64
A.S.C.E.	100	10001	10040	536	247	1000		5 3/4	5 3/4	2 3/4	9/16	1 45/64	3 5/64	31/32	13°	13°	Str.	2 66/128
"	90	9002	9040	535	245	999		5 3/8	5 3/8	2 5/8	9/16	1 19/32	2 55/64	59/64	"	"	"	2 45/128
"	85	8504	8540	531	235	850	851	5 3/16	5 3/16	2 9/16	9/16	1 35/64	2 3/4	57/64	"	"	"	2 17/64
"	80	8004	8040	530	251	800	800	5	5	2 1/2	35/64	1 1/2	2 5/8	7/8	"	"	"	2 3/16
"	75	7506	7540	529	214	750	753	4 13/16	4 13/16	2 15/32	17/32	1 27/64	2 35/64	27/32	"	"	"	2 15/128
"	70	7010	7040	532	237	700	701	4 5/8	4 5/8	2 7/16	33/64	1 11/32	2 15/32	13/16	"	"	"	2 3/64
"	65	6507	6540	534	236	650	653	4 7/16	4 7/16	2 13/32	1/2	1 9/32	2 3/8	25/32	"	"	"	1 31/32
"	60	6015	6040	533	244	600	603	4 1/4	4 1/4	2 3/8	31/64	1 7/32	2 17/64	49/64	"	"	"	1 115/128
A.T.& S.F.	90	9021	9021			9035*	903	5 5/8	5 3/16	2 9/16	9/16	1 15/32	3 5/32	1	4 to 1	4 to 1	1/16 to 1	2 37/64
Can.Nor.	80	8010	8010			804		5	5	2 7/16	35/64	1 13/32	2 11/16	29/32	13°	13°	1/16 to 1	2 1/4
Can.Pac	85		8524			856		5 1/8	5	2 1/2	9/16	1 7/16	2 11/16	1	4 to 1	4 to 1	1/32 to 1	2 11/32
"	65	6508	6508			654		4 31/64	4 3/8	2 1/4	15/32	1 9/32	2 11/32	55/64	"	"	1/32 to 3/4	2 1/32
C. of N.J.	133				290			6 1/2	6	3 5/32	3/4	2	3 9/32	1 7/32	14°	14°	4°	2 63/64
C. & A.	70	7002						4 3/8	4	2 35/64	35/64	1 17/24	1 11/12	3/4	12°	12°	1/24 to 5/16	1 17/24
C.B.& Q.	85	8506	8543			855*	852	5 3/16	5 3/16	2 21/32	9/16	1 35/64	2 3/4	57/64	13°	13°	5°	2 17/64
C.&N.W.	100	10035	10035					5 49/64	5 9/16	2 9/16	9/16	1 39/64	2 61/64	1 9/64	13°	13°	3°	2 70/128
"	72	7201	7250	581				4 3/4	4 3/4	2 3/8	[illegible]	1 13/32	2 1/2	27/32	14°	14°	Str.	2 3/32
D.L.&W.	101		10133		299	10130		5 7/8	5 3/8	2 3/8	[illegible]	1 23/32	2 11/16	1 3/32	13°	13°	4°	2 3/8
"	91		9133			911		5 1/2	5 3/8	2 3/8	[illegible]	1 41/64	2 11/16	63/64	"	"	"	2 17/64
D.&R.G.	90						906	5 1/2	5 1/2	2 9/16	9/16	[illegible]	2 7/8	1	14°	14°	4°	2 7/16
"	85						850	5 1/4	5 1/4	2 1/2	9/16	[illegible]	2 3/4	7/8	13°	13°	"	2 3/16

*—Not rolled now.

Type	Wt. Yd.	Ill. St. Old No.	Ill.St.Carn T. C. I.	Cambria	P.S.Co.	Lack St.Co.	Colo. F. & I. Co.	H	B	Hd.	W	D	F	E	A	Az	S	N
D&RG, C&S	85						853	5⅝	4⅞	2½	9/16	1 15/32	2 29/32	1	4 to 1	4 to 1	1/16 to 1	[illegible]
Dudley	90					901		5½	5	2 21/32	9/16	1½	3 1/32	31/32	4 to 1	4 to 1	1/16 to 1	[illegible]
Grt. Nor.	90	9010	9034	560	160	9030	904	5⅝	5	2⅜	⅝	1½	2⅞	1	13°	13°	5°	[illegible]
"	85	8509	8553			854*		5	5	2 21/32	21/32	1 13/32	2½	29/32	14°	14°	5°	[illegible]
"	80	8000	8009			802*		5	5	2 13/32	⅝	1⅝	2½	⅞	"	"	"	[illegible]
"	77½	77501				775*		5	5	2⅜	⅝	1 11/16	2½	13/16	"	"	"	[illegible]
HockingVl	80			540				5	4 59/64	2 21/64	29/64	1 96/128	2 25/64	111/128	13°	13°	4°	[illegible]
Ill.Steel	100		10090					5 9/16	5	2 21/32	9/16	1 37/64	2 31/64	1 3/16	4 to 1	4 to 1	1/16 to 1	[illegible]
Interb'g'h	100	10005	10005			1005		5¾	5¾	2⅞	9/16	1 45/64	3 5/64	31/32	13°	13°	8°	[illegible]
"	90		9050			902		5	5	2⅞	11/16	1 25/32	2 11/32	⅞	"	"	"	[illegible]
Lehigh Val.	110		11033					6	5½	2⅞	19/32	1⅞	3 1/16	1 1/16	4 to 1	4 to 1	4°	[illegible]
L. I. R. R.	150			562				4½	6	3⅜	2¾	1¾	1 1/16	1¼	13°	13°	Str.	[illegible]
Misc.	67	6704	6733	515				4½	4½	2 13/32	½	1⅝	2⅛	¾	13°	13°	1/16 to ¾	[illegible]
"	65	6501						4⅜	4 7/16	[illegible]	27/64	1½	2 9/32	23/32	13°45′	12½°	3½″ Rad.	[illegible]
"	60	6001	6051					4¼	[illegible]	[illegible]	½	1 7/16	2⅛	11/16	14°	12°50′	1/10 to 1	[illegible]
"	60	6017	6033	503				4¼	4 13/64	2 21/64	29/64	1 86/128	2 7/64	91/128	13°	13°	5°	[illegible]
Mo. Pac.	85	8507	8550			853*		5 7/32	5¼	2 15/32	75/128	1¾	2 39/64	55/64	13°	13°	2°30′	[illegible]
"	75	7512	7550	528	189	754		4¾	4¾	2 9/16	9/16	1 7/16	2 15/32	27/32	"	"	Str.	[illegible]
N. Y. C.	103½		10522			1051		6	5½	3	19/32	1⅝	3 13/32	31/32	4 to 1	4 to 1	1/16 to 1	[illegible]
"	100	10003			175	1001		6	5½	3	19/32	1⅝	3 13/32	31/32	"	"	"	[illegible]
"	80	8608	8022	543	220	801		5⅛	5	2 21/32	17/32	1½	2¾	⅞	"	"	"	[illegible]
NYC&StL	85	8521	8521			8531		5⅜	4⅞	2 17/32	17/32	1 25/64	[illegible]	63/64	4 to 1	4 to 1	1/16 to 1	[illegible]
NYNH&H	100	10004	10034					6	5½	2¾	19/32	1 23/32	3 11/32	15/16	13°	13°	4°	[illegible]
Nor. Pac.	66	6602	6602	547				4 17/32	4½	2 9/16	17/32	1 27/64	2 11/32	49/64	13°	13°	Str.	[illegible]
P.S.Penn.	100	10031	10031	558	96A	10030		5 11/16	5	2 43/64	9/16	1 13/16	2 25/32	1 3/32	15°	13°	3/64 to 1	[illegible]
"	85	8530	8511	559	67A	8530		5⅛	4⅝	2½	17/32	1 21/32	2 15/32	1	"	"	Str.	[illegible]
P. R. R.	100	10002		520	96	1003*		5½	5½	2 13/16	⅝	1⅞	2 11/16	15/16	13°	13°	4°	[illegible]
"	85	8503	8533	500	67	852*		5	5	2 9/16	17/32	1¾	2⅝	⅞	"	"	"	[illegible]
"	70	7005	7033	504	57			4½	4½	2 7/16	½	1 19/32	2⅛	25/32	"	"	"	[illegible]
P. & R.	100		10032		165			5⅝	5⅝	2 21/32	9/16	1 45/64	[illegible]	1 1/16	13°	13°	3/64 to 1	[illegible]
SeaAir Line	85		8522					5¼	5	2 11/16	17/32	1⅝	2¾	⅞	14°	14°	1/16 to 1	2¼
"	75		7522					5	5	2 9/16	½	1⅝	2¾	⅞	"	"	3°	2¼
Soo. Line	85	8520	8520					5⅜	4⅞	[illegible]	9/16	1 15/32	[illegible]	1	14°02′11″	14°02′11″	3°34′35″	[illegible]
U. P.	90	9003	9023				901	5¾	5⅝	2¾	17/32	1½	3⅜	⅞	13°	13°	Str.	[illegible]
"	75	7513	7523				754	5	5	2 9/16	33/64	1⅝	2 13/16	13/16	"	"	"	[illegible]
"	75	7524	7524				757	4 15/16	4 7/16	2 7/16	33/64	[illegible]	[illegible]	15/16	4 to 1	4 to 1	1/16 to 1	[illegible]

A. Standard Rail Section of A. S. C. E. (adopted 1893.)
100 lbs. per yd.

Area of Head	4.13 sq. in.	42%
" " Web	2.06 " "	21%
" " Base	3.63 " "	37%
Total	9.82 sq. in.	100%

Moment of Inertia, 43.8
Section Modulus, Head, 14.44
Section Modulus, Base, 16.11

B. Standard Rail Section of Am. Ry. Assn., Series "A" (recommended 1907).

Area of Head	3.64 sq. in.	36.9%
" " Web	2.29 " "	23.4%
" " Base	3.91 " "	39.7%
Total	9.84 sq. in.	100.0%

Moment of Inertia, 48.94
Section Modulus, Head, 15.04
Section Modulus, Base, 17.78

C. Standard Rail Section of Am. Ry. Assn., Series "B" (recommended 1907).

Area of Head	3.95 sq. in.	40.2%
" " Web	1.89 " "	19.2%
" " Base	4.01 " "	40.6%
Total	9.85 sq. in.	100.0%

Moment of Inertia, 41.3
Section Modulus, Head, 13.70
Section Modulus, Base, 15.74

D. Standard "P. S.'" Rail Section of Penna. R. R. System (adopted 1907).
100 lbs. per yd.

Area of Head	4.09 sq. in.	41%
" " Web	1.85 " "	19%
" " Base	4.03 " "	40%
Total	9.97 sq. in.	100%

Moment of Inertia, 41.9
Section Modulus, Head, 13.71
Section Modulus, Base, 15.91

Section (Fig. 24)	lbs. per	Dimensions of Rails, in inches						Thickness
		Height				Width		
	yd.	Total	Base	Web	Head	Base	Head	of web
A. S. C. E.	80	5	7/8	2 5/8	1 1/2	5	2 1/2	35/64
	90	5 3/8	59/64	2 55/64	1 19/32	5 3/8	2 5/8	9/16
	100	5 3/4	31/32	3 5/64	1 45/64	5 3/4	2 3/4	9/16
A. R. A. Series "A"	80	5 1/8	31/32	2 23/32	1 7/16	4 5/8	2 1/2	33/64
	90	5 5/8	1	3 5/32	1 15/32	5 1/8	2 9/16	9/16
	100	6	1 1/16	3 3/8	1 9/16	5 1/2	2 3/4	9/16
A. R. A. Series "B'	80	4 15/16	1	2 15/32	1 15/32	4 7/16	2 7/16	35/64
	90	5 17/64	1 1/32	2 5/8	1 39/64	4 49/64	2 9/16	9/16
	100	5 41/64	1 5/64	2 55/64	1 45/64	5 9/64	2 21/32	9/16
P. S.	85	5 1/8	1	2 15/32	1 21/32	4 5/8	2 1/2	17/32
	100	5 11/16	1 3/32	2 25/32	1 13/16	5	2 43/64	9/16

"On lines of intensive operation where the available intervals between trains are never more than 25 min. and where intervals as low as 12 min. must frequently be utilized it is of the utmost consequence that the preliminary work be done to the last item. No single operation that can be completed before the track is broken must be omitted. The cutting of a closing rail is entirely out of the question and this must be provided for beforehand by careful deter-

mination with the steel tape. The number of rails that can be laid in a given interval must be known and though this is somewhat variable it will be found close to a rail a minute for intervals between 10 and 25 min.

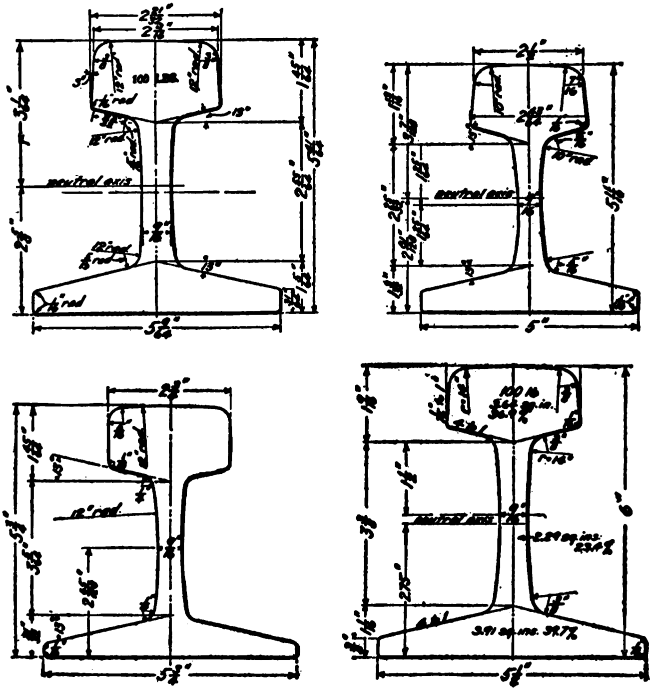


Fig. 24. Standard Rail Sections for Steam Roads

"The rails must be as near the place where they are to be applied as possible and all needed material must be close at hand. The distant flagman must be trained to receive instantly the flag signal to begin

protecting and must respond just as promptly when the signal is given to withdraw. The need for immediate action by each member of the rail laying force is no less insistent.

"There is no item of work wherein the matter of detail is of such importance as rail renewal, which of necessity causes a break in the track. A specific duty is laid upon each member of the gang and remains for every operation, so that no further line-up is required. Maintenance rules generally require that the rails shall be laid one at a time and similarly forbid the withdrawal of spikes or the removal of bolts in advance of the renewal. This severe but necessary restriction can be met by perfect organization.

"The bolts at the joints to be broken have washers added until the nut has just a safe hold. Two of the best workmen are assigned to each end of the run to be relaid. Ten men with claw bars are delegated to remove from the chosen side of the rail the spikes which have previously been started to assure their coming out readily. Eight men with lining bars push the old rail aside, two dislodging it, one guiding it across the new rail and five lining it away. Four men follow closely, two with spike mauls and punches to drive down the butts of broken spikes, one with an adze and one with a stiff broom to sweep aside chips of wood, pieces of ballast and spikes. Twelve men with tongs put the new rails in place as fast as the old are removed and 10 men working in pairs apply the splices with half their complement of bolts. Two men push the rail under the spike heads and spike the joints and centers while the 10 men who were pulling spikes but who are now free spike the rail upon every other tie. Four utility men put the cut rail in place and look after the compromise joint in case a different section is being laid. The gang which threw out the old rail completes the full spiking and the men with

the tongs assist in applying the remaining bolts, giving them all as full tension as possible. This force of men generally consists of two gangs and, in addition to foreman and assistants, numbers about 50 men.

"The preliminary work in renewals of this character largely determines the efficiency of the gang. In the event of a different section of rail being used in renewal, the first work upon the arrival of the relaying gang is to remove the tie plates, the ties that were without tie plates being adzed down when these are in the minority and those surfaced up that carried the tie plates when they are in the minority. After this is done the detailed surface of the track is given attention so that the new rail may lie upon as smooth a bed as possible. The ties must then be adzed to a level seat alongside the rail. The point of beginning must next be established and where possible this should have especial regard for the existing locations of block joints when these cannot be changed so that the introduction of unusual lengths of rail in the main track at isolated points may be avoided. In the event that this necessitates laying the rail against the current of traffic, temporary rails of the new section are used so that the approach ends of the permanent rails will not be injured. The rails are then strung out just outside the ends of the ties to be as near their final positions as possible and incidentally to indicate the new positions of the joints for use in the preliminary tie spacing. This method is not accurate on sharp curves and the position of the joints must be determined in such cases by careful measurement with a steel tape after the average length of the new rails has been carefully ascertained. When the rails are set up for the purposes named it would be an unnecessary refinement to use shims and many of the shims would surely become lost. It is quite sufficient to place a number of the rails, five in summer weather,

with their ends in contact and separate each five with a spike, which represents the aggregate of the several spaces.

"When the preliminary spacing is completed so as to assure the flanges of the splices entering without exception, the word is given and the men line up to await the foreman's signal that use of track has been given, communicated from the telephone box or from his field telephone connected with the despatcher's telephone line. The principal protection is the distant flagmen, who not only display a red banner but place torpedoes on the rail. The signalmen, whose duty it is to bond the track further by means of a wire shunt the track circuit so as to display the danger signal at the nearest signal; but at the immediate location the foreman's red flag is always in evidence until replaced by a white one to indicate that all protection may be withdrawn and traffic be allowed to run as usual. This assumes that all ties are fully spiked, all bolts inserted and made tight and at least two bond wires are in place at each joint."

IX

EFFECTS OF THE WAVE MOTION OF RAIL ON TRACK RAIL MOVEMENTS

As all rail movements are on the principle of the lever, there is of necessity an undulatory motion during the passage of every train, the principle of which is illustrated in Fig. 25. The amount of this is dependent on the condition of the sub-grade, ballast, ties, rail and weight of the rolling stock. Any weak-

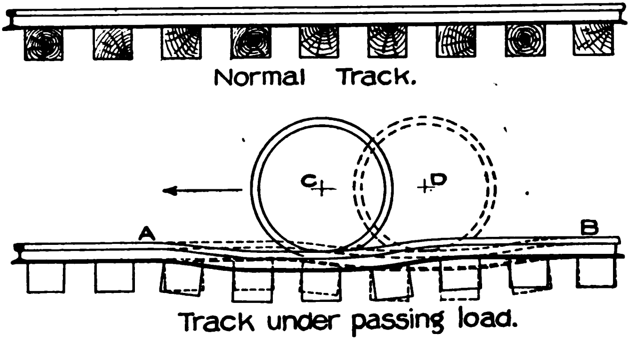


Fig. 25. Wave Action of Track Under Wheels

ness in the drainage, ballast, ties or rail will at once show itself when put into use. If not corrected at once this will increase, and the destruction it can cause is likely to be serious. The less substantial the superstructure the greater ballast compression there will be, and, of necessity, rough-riding track.

If water be permitted to collect under the ties in a short time they will churn, which action, unless taken care of, will prove destructive.

Movements or vibrations of any kind are objectionable in the track; and for that reason wood and stone are used to absorb these as much as possible.

The undulatory motion of the rail has the following injurious effects:

1. Compresses the ties in the ballast.
2. Churns the ties.
3. Cuts the ties at the rail base.
4. Displaces the ballast.
5. Injures the roadbed.
6. Injures the rail.
7. Causes the rail to creep.
8. Wears the angle bars.
9. Wears the bolts.
10. Raises the spikes.
11. Wears the spikes.

Ballast compression. The different functions that a tie performs must be taken into consideration.

1. It holds the rails to gage.
2. Supports the rails.
3. Distributes the weight of the passing wheel loads to the ballast and roadbed.
4. Resists compression into the ballast.

It is claimed by many that the ties act as abutments, and the rail deflections occur between these. This was finally proved to be an error.

Churning of ties and displacing of ballast. The foundation of all ties being loosely compacted material, any movement of the tie, or what is commonly called "churning of the tie," necessarily throws unequal loading on the ballast at different times, causes its compression and movement, and destruction of the tie foundation. The wider the ties and the lighter

the rail and the heavier the loads, the greater such movement must necessarily be.

Assume, for instance, two wide ties and a light rail, and over them a heavy wheel load, midway between the ties. This rail will bend under these conditions and take the form of a curve, thus throwing the wheel load on the near edge of each tie, producing an eccentric loading of the tie, greater compression under the edge of the tie that is loaded than on the opposite edge, and, necessarily, a slight movement of the tie to adjust itself to these conditions. When the wheel moves to the opposite side of either of these ties the conditions are reversed, and thus the churning takes place.

Injury to the roadbed is a necessary sequence of the ballast displacement, and is augmented by the amount of water standing in pools on the bed.

Injury to the rail. According to Professor Dudley, rails take a permanent set, as regards wave motion, in one of three forms:

1. Joint low and center high.
2. Joint and center low, quarter high.
3. Entire rail wavy.

The first occurs in rails which are laid with the joints square or opposite; consequently the low places are found at the weakest point, the joints, while the centers are high.

The second form is met with in rails which are laid with their joints broken. The weak point being the joint, it deflects in time, and trouble also appears in the opposite rail at the center. On this line of reasoning, if it is low at one point it must be high at another, which is the quarter.

The third form appears in the rail where the ties have been tamped unevenly, there being alternate hard and soft spots in the bed.

Wear of angle bars and bolts. At the joints there are several parts working independently—the two angle bars, the bolts, nuts, nut locks, rails, ties, and, to a certain extent, the spikes and ballast. Now, the least particle of vibratory motion destroys the mutual relationship between these parts, and wearing is the result. The principal wear is on top and underneath the bar, where the rail rests, and, in turn, where the bar rests on the rail. The bolt holes are also enlarged. The bolts, being a portion of the joint fastening, also wear, and in time are unfit for use.

Raising of spikes. As the vibratory motion of the rail takes place, something has to give way. If the fastening to the tie is by push bolt or lag screw, the tie will be raised with the vibration and " pump " the ballast. This action will take place for a while, but in time these fastenings will become loose. If the rail is held down by a spike, the tendency is to raise it an exceedingly small amount, enough to allow for the play of the rail. Spikes are either re-enforced under the head or perfectly plain. It is at this point that the re-enforcement is injurious, for whether it is in the back or front of a spike, raising it affords the rail an opportunity to move laterally by the amount of extra metal in the neck. As the re-enforcement inclines toward the vertical axis of the spike as it extends down the neck, the further it is extracted from the tie the larger the opening left for the spike to fill up; hence the spike is crowded backwards in the hole and the rails have a chance to spread. In short, there should be no re-enforcement on the neck of a spike.

Tendency of rail to work into face of tie. When the spike is slightly higher than its normal position in the tie, the rail has an opportunity to act on the tie more than otherwise. This action partakes of three different forms:

1. A straight pressure downwards.

2. A lateral pressure.
3. A resultant of these two.

Wear of spikes. The rail has an opportunity to work up and down, wearing the neck of the spike.

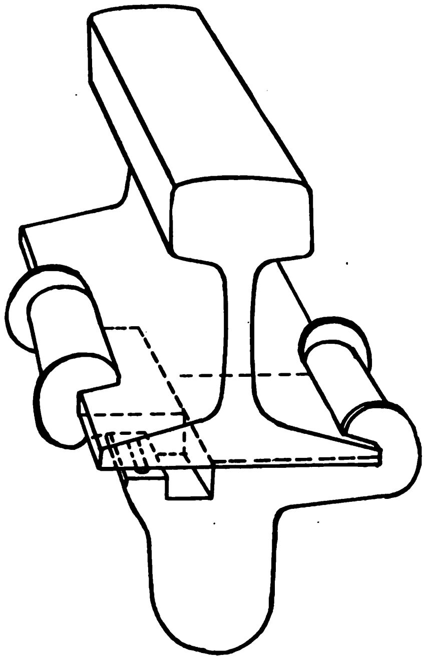


Fig. 26. The P. & M. Anti Rail-Creeper
Two Simple Parts—No Bolts

The same action takes place when a spike is not driven properly.

Wear of rails. When a rail is unduly canted all the running is done on one side of the head, and, consequently, this is where the surface wear takes place.

Creeping rails. Creeping is caused by the undulatory motion, and is very destructive to track. Not

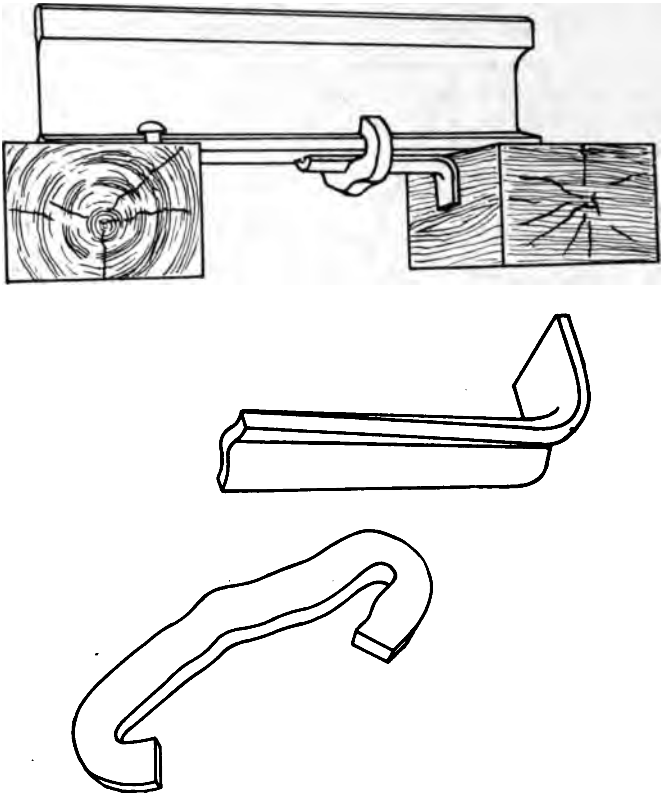


Fig. 27. The "Dinklage Creep Check"

only does it buckle the joints and tear apart the bolts, but also disturbs the ties, especially those at the joints, and displaces the ballast. This is arrested in part by

the slot holes in the angle bar, but anchors of some sort should be used in addition. Many devices for this purpose are on the market, a number of which are illustrated in Figs. 26 to 29 inclusive. In stone ballast, tamping ties on the leaving side materially assists, as well as driving the outside spikes on the leaving side.

Rail creeping. Mr. G. Van Zandt published, in

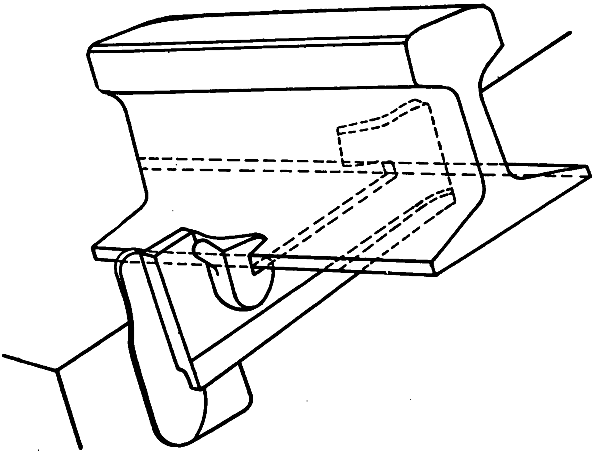


Fig. 28. The Vaughan Rail Anchor

Railway Engineering and Maintenance of Way, the following article, which is here given substantially in full:

"Among the peculiar phenomena of the maintenance of railway track, one of the most interesting (and sometimes most perplexing and troublesome) is the continual movement of the rails along the ties. It has long been observed by trackmen and engineers and many interesting accounts have been published in

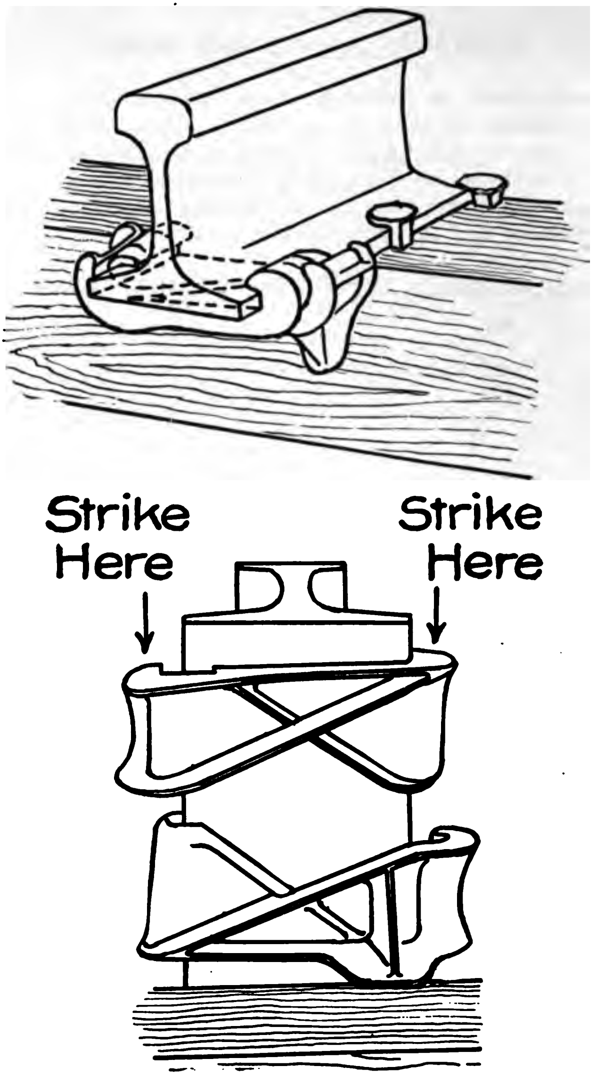


Fig. 29. The Holdfast Rail Anchor

regard to this movement with theories accounting for the action.

"Rail creeping has been found to assume astonishing proportions and to cause a large number of wrecks in some localities. An incident often quoted in this connection is given by Mr. Thomas Keefer of the Canadian Pacific Ry. (Am. Soc. C. E. XIX. 1888) who witnessed a movement of over two feet with the passage of a single train over a 'muskeg' or swampy locality. In many cases it is reported to have moved around sharp curves and to have straightened out on the following tangent or reversed on a following curve.

"The results to the track are well known to trackmen who have to continually combat this tendency. 'The movement,' says Mr. Camp (Am. Soc. C. E. 1904), 'causes trouble and expense in many ways. It shoves joint ties off their tamped beds upon loose ballast; frogs are crowded out of alignment, and wrecks are not infrequent from such causes.' Signals and switches are put out of order and splice bars broken, so that constant inspection is made necessary to insure safety of operation. The alignment at crossings is often disturbed and many irregularities of track are due to the accumulative creeping of the rails. At summits rails have separated several feet, the bolts shearing off or splice bars breaking and track crowding in the sags where kinking out of alignment frequently occurs.

"Numerous appliances known as 'anti-creepers' have been devised to prevent this movement, some of them combining the splice bars with the holding device. These generally consist of a plate fastened to the rail and held to the tie so that any movement of the rail will be retarded by the resistance of the tie in the ballast. The result has been unsatisfactory, in many cases, because the ties have moved with the rails and 'bunched' before the creepers; however where

creeping is not excessive 'anti-creepers' have prevented appreciable movement.

"For obvious reasons it is not desirable to run the risk of throwing additional stresses into the bridge structures by attempting to hold the creeping rails by 'anti-creepers.' Hence in many places the rails are left free to move across the bridges. In some localities there is very little trouble from creeping and no provision is made for it. In other places the placing of blocks between ties to reduce the wave-motion of the rail has been used more or less successfully. In some bridges, however, it has been a difficult problem, especially with long spans giving considerable deflection, and especially where the elasticity of the ties beneath adds to this depression by remote support. The Eads Bridge across the Mississippi River at St. Louis, Mo., has an excessively heavy traffic and has the remarkable record of rail creeping, forty-two (42) feet in a single month.

"In this bridge, devices have been made for handling the rail as its moves, switch points being placed where the process begins and ends. At eight points on the bridge these 'creepers' are located, requiring the services (day and night) of eight men. A full description (Sci. Am. Mar. 24, 1900) of the 'Irishman,' or rail creeper, has been given by the superintendent of the structure, who states that 'the creeping occurs not only on the bridge but also on the approach trestles. It is always in the direction of the traffic. The movement is dependent upon the elasticity of the track supports and varies with the tonnage passing over the rails. An attempt was made at one time to check the movement but the strain on the fastenings was sufficient to tear fish-plates in two and shear off seven-eighths inch track bolts.' 'A further study of this bridge,' states Mr. J. B. Johnson (Journal of Ass'n. of Eng. Soc. Vol. IV, Pg. 8, 1885),

'reveals the secret of the causes of the phenomena. The tendency is due to the wave motion, causing the rail to be longer than the corresponding linear distance. The rail is seen to roll along on its base and move as much as the base is longer than the neutral axis.' A careful study of the depressions of the track, due to this rolling load, reveals the following:

"(1) There is first a rising of the rail from the tie at a point about ten feet in front of the wheel.

"(2) A deep and rapid depression follows as the load approaches, reaching a maximum under the wheel.

"(3) Between the wheel loads there is a slight rising of the rail varying with the weights and the distance between them.

"(4) The forward motion occurs just in front of each wheel.

"Figure 30 is a diagram showing the motion as theoretically determined by Mr. Johnson. The load advances from P to p and the base is held down by the weight upon the rail so there can be no movement backward. The frictional hold would probably be thirty per cent or more of the weight upon the tie, not to mention the grip of the spikes, etc. It is obvious that while depressed under a wheel load the base of the rail is on the circumference of an arc of greater radius than the neutral axis. Since the base cannot slip the neutral axis must move forward the difference between lengths of the arcs. As there is a difference between the length of the neutral axis when horizontal and when on the curve, in the rolling of the wheel load there must be an elongation or a movement. If there were no wave motion beneath the train and the depression were uniform, the depressed curved track would evidently be longer than the original horizontal track since the straight line is shorter than a curve. It would appear, therefore, that the

advance wave and depression, together with the resilience wave in the rear are the causes of the horizontal motion of the rail.

"On the basis of the above theory, it follows that,

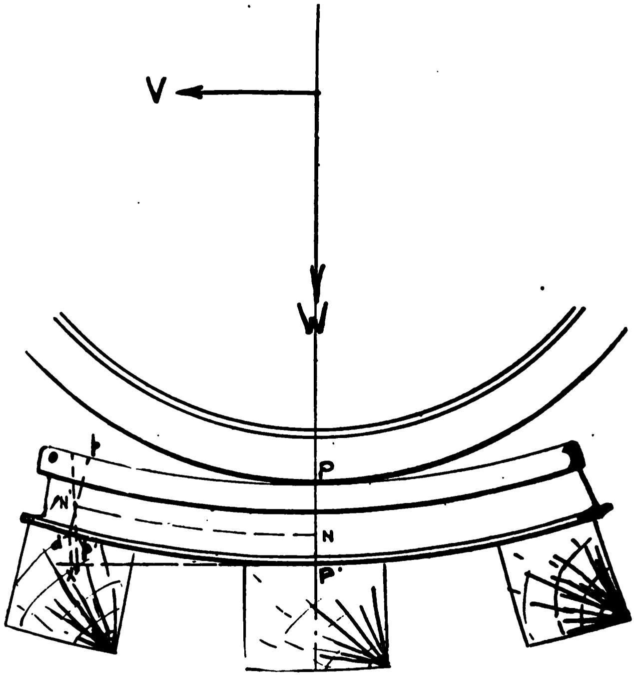


Fig. 30. Wave Motion, Cause of Creeping

should the rail be supported in some manner from the top, it would move in the opposite direction. This it has been shown actually to do upon a model constructed for the purpose. This model was prepared

with a wooden rail mounted on springs and free to move. A rolling weight was moved around a circular track causing deep depressions. A forward motion was very apparent when the rail was supported at the base and a similar backward motion when the rail was supported from the top. A practical demonstration of this action has also appeared in bridges which show a marked tendency to move on their supports unless held by rigid connections. Through spans are thus forced forward and deck spans backward."

Many contradictions appear among the observations of creeping rails; some observers declare that the outer rail on curves creeps more than the inner, whereas others claim the reverse, and, similarly, some state that on tangents the right hand rails move more than those on the other side (in the direction of traffic). A typical report of investigation is found in the record of the annual meeting of the Roadmasters' Association of America, 1898, a part of which is quoted below:

"Rails creep in the direction of traffic on double track lines. This creeping is found to be the greatest on down grades and worst where tracks are laid over marshes.

"It has also been ascertained that on curves the outer or higher rails creep the more.

"The cause of creeping track is the rolling load passing over it,—producing a wave motion.

"It is doubtful if a remedy exists or can be found.

"The most common method is to rely upon anchorage. Three-tie joints give best anchorage but do not prevent creeping.

"The best method is to restrict the wave motion, which can be done only by having a stiff rail to transmit weight over greater area of ties and ballast, track to be well tied, and ballast dressed off full at the

ends of ties (to prevent skewing of ties and tightening of gage) but to allow for drainage.''

Reference is made to the experiments of Mr. Howard on the C. B. & Q. R. R. for the determination of the rail depressions. (Watertown Arsenal Reports, 1905.) A long series of tests was made and the results carefully prepared, showing the actual depressions under different loads with different rails and roadbed conditions. It was found that, generally speaking and other things being equal, of the three kinds of ballast used, viz., stone, gravel and cinders, the gravel ballast gave the least average depressions. The advance wave was well demonstrated and found to be eight to ten feet in front of the locomotive and to rise to a level about one-fourth of one inch above the depressed track under the wheel load. A series of readings was also made with a spirit level to determine the slope of the rail as the loads passed over it. From these it appears that there is a hump in the rail immediately preceding each wheel like that produced by sliding a heavy weight over a carpet. This, of course, is true for moving loads only, and considerable difference would be found if the locomotive were to be let down upon the rail from above by a crane, thus giving static depression curves.

A number of interesting experiments are given by Mr. P. H. Dudley, who invented a micrometer for measuring the strains in rails. His results are interesting, revealing the stresses due to these depressions and concentrations of weight. He concludes that ''heavier rails distribute the weight better,'' the design being an important element. ''The dynamic effects increase with the roughness of the rails and treads'' and with the speed, especially on track with many irregularities. New rails do not appear to show a reduction of wave motion, probably on account of their non-conformity to the worn treads of the wheels.

It has been observed that "it requires two years and over before heavy rails reach their best condition in the track." The readings of the stresses in the rails indicate that the "strains increased 14.3 per cent, with an increase of speed from two to ten miles per hour." Reverse stresses were recorded between wheels, indicating compression on the base of the rail. It appears, therefore, that the resilience of the track-bed tends to bend up the rail as soon as the wheels have passed over. It is noticeable that light passenger locomotives with wheels separated by greater distance give greater wave motion than the heavier freight locomotives with drivers bunched together.

A very interesting series of experiments is recorded by Mr. Wagner (Amer. Soc. C. E., Vol. 53, p. 466, 1904), giving actual observed experiments of track covering long periods of time. The results show that,

(1) Of the 32 points measured, 21 showed no difference between the movements of right and left rails; 8 showed more for right and 3 the more for the left.

(2) In seven of twelve observations, the greatest creeping was on down grades; five on level showed no difference.

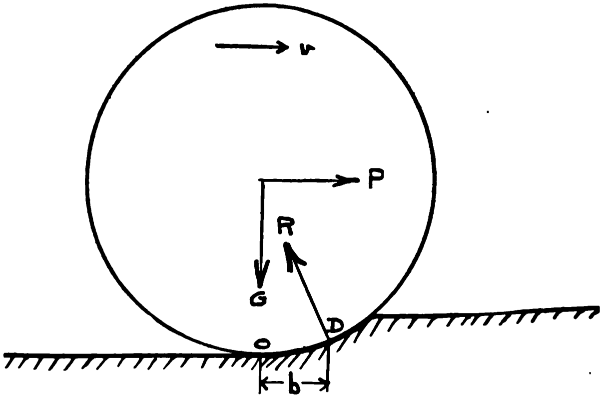
(3) More creeping was observed to occur on embankments or over swampy ground.

(4) More creeping appears on imperfectly maintained track.

Mr. W. M. Camp ("Notes on Track," p. 584) states that "there are two longitudinal movements on rails; one, a molecular movement of expansion or contraction in the metal, the other a progressive shifting of the rails bodily, commonly known as 'creeping' or running." He states also that the "creeping is most rapid during hot weather," and "it is greater on double than on single track," and further that it is generally in the direction of the traffic. The manner of the creeping and the amount depend upon "(1) the

character of the ground or foundation for the track; (2) the direction in which the train loads are the heavier; (3) the proportion of the weight distributed on the two rails; (4) the speed of the trains; and (5) the manner in which the ties are spiked."

The actual value of rolling resistance is difficult to determine as any data are likely to include some of the many other factors which go to make up train resistance.



Figure

Fig. 31. Direction of Rolling Resistance

"That it is a very insignificant part of train resistance" is the contention of Mr. Webb (Economics of Railway Location, p. 181). Mr. I. P. Church, in "Mechanics of Engineering," states that "the word 'friction' is hardly appropriate except when the roadway is perfectly elastic." Referring to Figure 31 he continues: "The track being compressed, its resultant pressure is not at O vertically under the centre, but some distance O-D in front. The 'rolling-resistance' is therefore

$$R = b \div \text{radius} \times \text{weight}.$$

where 'b' is the small distance O-D."

Mr. Pambour gives as the result of experiment on railroad wheels of cast-iron 39.4 inches in diameter.

$$b = .0196 \text{ to } 0.0216 \text{ inches}.$$

"If the force of resistance or the resultant can be assumed as acting normal to the track at the centre of the area of contact, we have a triangle of forces one angle of which can be approximated by the slope tests above mentioned. After working out a series of results in this manner, the values shown in the table below were obtained.

Table of rolling resistance or "rail push."

Wheel	Load (Axle) Pounds	Slope Per Cent	Resistance Pounds	#/Ton	Total Pounds	Remarks
Pilot	..11,000	0.0241	22.14	4.02		Rail 85 lbs. A.S.C.E.
Driver	26,500	0.0149	32.904	2.48		Stone Ballast
"	27,500	0.0110	25.205	1.84		Oak Ties
"	31,300	0.0065	16.984	1.08		
"	28,500	(—)0.0025	(—) 3.854	0.03	93.343	or 1.51#/Ton
Tender	15,950	0.0125	20.913	2.52		
"	"	0.0080	10.633	1.33		
"	"	0.0190	25.251	3.17		
"	"	(—)0.0010	12.287	1.66	43.510	or 1.36#/Ton

"Similarly with a passenger locomotive and tender it was found that with 70-lb. rail and gravel ballast the rolling resistance of the engine was 2.21 lbs./ton and of the tender 1.59 lbs./ton.

"The above analysis demonstrates the fact that the rolling resistance is a small part of the train resistance, probably seldom reaching as much as 1 per cent of the weight in any well maintained track. Further, on the basis of the above analysis of rail creeping, the rolling resistance is not all taken up by the rail by 'glancing blows,' but is communciated to the track below and results in the depression of the earth or 'settling' of

the track so commonly observed. It is not improbable that a part of this energy is consumed in producing the forward movement of the rail, but this would not be an important factor in its determination. The statement has been made that rolling resistance increases on curves, but evidently resistance other than the 'rolling friction' was taken into consideration and it is probable that in a more careful investigation it would not be materially different on curves of ordinary radius than on tangent. In the light of the above it appears improbable 'that there would be no creeping with a continuous rail,' as Mr. Lindenthal asserts. If the rolling resistance is the controlling factor, there is no reason why a continuous rail would remove creeping. The concussive and oscillatory factors would be materially reduced as with any item improving the track condition, but any improvement of the track reduces wave-motion as well and in this way only may reduce creeping.

"The prevention of rail creeping has always been a serious problem of track maintenance. Of the many appliances now on the market, few attempt to remove the cause of the greatest part of this movement. To summarize the conclusions of practice, we find the following recommendations:

"(1) *Good track.* If alignment, drainage, ballast, tieplates, spiking, are all first class, much of the creeping can be prevented. 'Track inspections show that almost invariably the rails on the outside of double track are subject to greater average deflection.' (Camp, Notes on Track, p. 588), and this is due to the lack of ballast on the ends of ties and shows the importance of the suggestions made by the committee of the Roadmaster's Association above quoted.

"(2) *The desirability of traffic moving in both directions* over the same track and the equalizing of tonnage in each direction.

"(3) Most of all, the necessity of *removing the cause of the wave-motion* by preventing depressions of large amount under wheel loads.

"If the other conditions are well taken care of, then the only remaining cause of consequence is the rolling of the rail on its base as above described. It is evident that to overcome this effect, it is necessary to support the rail at such a place above the neutral axis that the tendency to move backward due to wave-motion will counteract the forward tendency due to the difference in length of the curved and the straight rail.

"This requires a new rail of such shape and a support of such design as will fulfill the conditions stated. This would also mean a design to meet the special conditions of each locality where great trouble is found with creeping. A rail somewhat approaching this design is found in use in England where creeping is almost unknown. The rails are not supported by the head, but prevented from moving sidewise by supports which are wedged against the web directly under the head, and they doubtless transmit some of the concentration to the tie. (See Fig. 32.) Some

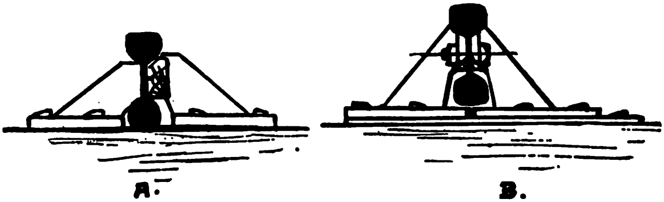


Fig. 32. English Rail Section to Prevent Creeping

similar system could be used in localities of much creeping and ought to remove the cause of the difficulty. In the figure it is suggested that 'B' supports the rail under the head and leaves the base free to

move with the inevitable wave motion, but there would be no tendency to move forward. This would require the use of the English rail section, which for many other reasons might be undesirable.

"As a practical solution of the problem, on long span bridges such as the Eads bridge above mentioned, the type of construction shown in Figure 33 is suggested. This might also be found of advantage in

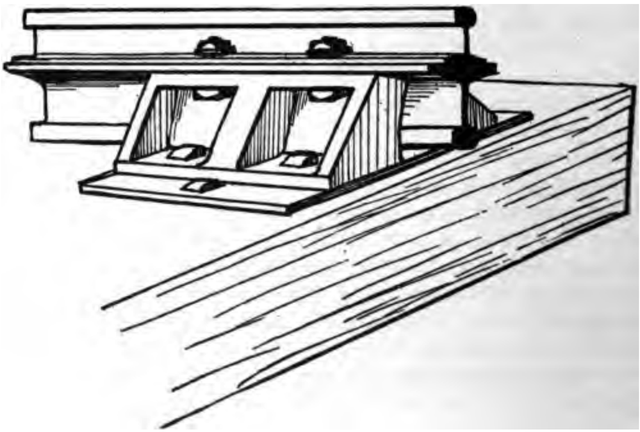


Fig. 33. Special Rail Section to Prevent Creeping on Bridges

other places of excessive rail creeping. Two rails are turned base to base and bolted together with track bolts. The two sections are so selected that the neutral axis lies sufficiently below the point of support to counteract all tendency to move forward. The support is of such design that the weight is well distributed and investigation shows that there would be no danger of deformation or shear with ordinary rails and present loads.

"Rolling loads upon passing over this track would produce some wave motion, but that which would be produced, would be taken care of in the backward motion of the head of the under rail. All the causes would therefore be removed and the conditions would be fulfilled to prevent the rail from creeping.

"Comparative observations have been made upon bridges which have stringers directly under the rails and those supporting the rails on the ties at some distance—as in the support of double track on three stringers. A very marked increased creeping is noticeable on the design involving the elasticity of the ties.

"In conclusion, it appears that by the close study of all the conditions, including the design of the bridge floors, and the preparation of the track, practically all the rail movement may be eliminated in a way which when applied to the bridge spans will not bring undesirable stresses into the structure.

"The use of the precautions above noted, together with anti-creepers, on good track on which trains are run in opposite directions with approximately the same tonnage, should completely eliminate the creeping of the rails and its attendant evils. Too much emphasis can not be laid upon the desirability of good drainage for it is necessary that the depression of the rail, under the wheel load, should be a minimum, and this requires that the roadbed should be firm and well drained."

Practical conclusions by the authors. In commenting upon the above interesting article and giving the theoretical reason for the creeping of rails and such suggestive theoretical methods for avoiding such trouble, we would note that up to date the most satisfactory and practical solution of the difficulty has been to employ rail anchors or anti-creepers, the judicious use of which nearly always results in an entirely satis-

factory solution. The number of anchors or anti-creepers used should be proportioned to the amount of creeping force developed by the conditions of road bed and traffic. It need hardly be remarked that while it is desirable to have the same amount of tonnage in each direction in order to avoid creeping, no railroad is going to regulate its business for the purpose of eliminating the creeping of rails, this being very desirable from a laboratory and experimental standpoint, but utterly impractical from the point of view of the railroad business.

The relative cost of maintenance of unanchored track and track anchored to prevent creeping of ties is shown in an article in the Railway Age Gazette. The data are taken from records made on the maintenance of 3½ miles of double tangent track of level grade, light gravel ballast, 85 lb. rail and broken joints. The heavy traffic was north bound and consequently all data are based on the north bound track, as the creeping tendency here was decided. This track had been put in service 14 months before, and one mile in the center of the stretch was anchored, leaving 1½ miles on the north and one mile on the south end not anchored. Where the track was anchored, 640 anti-creepers were applied, two per rail length, opposite joints against opposite end of joint ties. The anti-creepers have received no maintenance and have shown no failure, although they had been in service 14 months at the time of inspection.

The kind of work done on the two pieces of track in 14 months was as follows:—The anchored track was resurfaced once, while the unanchored track was resurfaced twice, the ties thereon were spaced twice and the rail driven back twice.

The total maintenance cost for the mile where the anti-creepers were applied, including the cost of anti-creepers, is as follows:

Cost of anti-creepers, 640 at 17½c each	$112.00
Applying 640 anti-creepers at ½c each	3.20
Resurfacing, 10 men working 16 days, at $1.55 per day	248.00
Total	$363.20

The total cost of the next mile north of the mile where the anti-creepers were applied, subject to the same conditions of traffic, roadbed, etc., but unanchored, is given below:

Cost of resurfacing twice, each time 10 men, 16 days, at $1.55 per day, $248	$ 496.00
Cost of respacing ties twice, each time 10 men, 17 days, at $1.55 per day, $263.50	527.00
Cost of driving back rail twice, each time 10 men, 2 foremen, 6 days, at $1.55 per day, $111.60	223.20
Total	$1,246.20

This shows a saving in 14 months of $883 in favor of the anchored track.

It will be noted that the original cost of the anti-creepers and of their application have been included in the first 14 months. These costs are properly chargeable over the total number of years anchors are in service, which in all cases is at least as long as the life of the rail on which they are applied. This would make the saving considerably greater than has been estimated. Furthermore, this maintenance cost does not include injury done to ties, spikes and joints, which was considerable where anchors were not applied, as the creeping had pulled the ties badly askew, bending or completely destroying the spikes and often causing broken joints. Where the anti-creepers were applied, the wear and tear were hardly worth considering.

X

GENERAL FALL TRACK WORK

Track foremen will find plenty of work to do during the fall months before the ground freezes, preparing their sections to go through the long winter months with as little repair work as possible. If the weather is good more track work can be done in one month before the ground freezes than can be performed during the whole winter.

Section foremen should find all the places needing attention and repair them in the best manner possible.

Special care should be given to improving the surface of the track and putting a perfect line and gage on the rails.

The roadbed should be cleared of weeds and grass and the ballast along the shoulder of the track and between the rails should be dressed up neatly; joint fastenings should be made tight, and the ditches in all cuts cleaned out.

Any rotten ties remaining in the track should be taken out and replaced by new ones.

All new rail should be laid before cold weather. The joint ties should be spaced properly and ballast put under the track, and at other points requiring attention where new rail is not laid good repair rails should be put into the track to replace the ones that have become battered. Grass should be cut while still green and no rubbish allowed around the wood work of bridges, culverts or cattle guards. Rubbish should be gathered up and burned.

In a prairie country the grass along the right of way on both sides of the track should be burned off clean as soon as it is dry enough, and the tops of the cuts should be burned off first, to prevent the locomotives from setting fires on farm lands adjoining. All right of way fences should be examined and repaired and snow fences put in good condition to be ready for the first snow storm. All track material should be piled at headquarters or regularly designated points, a safe distance from the track where it cannot cause snow drifts.

Rails, splices and such other material should be raised from the ground and piled upon platforms of old ties so that there will be no difficulty in handling them after snow falls.

All ties, fence posts, or lumber should be piled up with spaces between the piles so that fire can not communicate to a large quantity at once. Emergency rails and angle bars should be placed at the mile posts along the section, to be handy in case of broken rails.

Much of the fall track work is the same as that done during the spring or summer, but foremen should be particular to do at this season of the year all work which can only be imperfectly done in the winter, or must wait over until the following spring if not attended to now.

Cleaning the right of way. In the latter part of the month of July, or before the weeds growing along the railroad right of way run to seed, the section foreman should commence mowing and cutting down all grass, brush and weeds from the shoulder of the track out to the right of way limits.

The grass and weeds growing around the ends of culverts, or close to the bridges, should be mown down, while the surrounding grass is still so green that it will not burn, in order that the mown grass, when dry, may be burnt without danger of the wind

spreading the fire, and to prevent other fires from reaching the wood work when burning off the right of way afterwards. In localities where the sections are long and only a small force of men is employed the right of way mowing is sometimes done only for a short distance out from the shoulder on each side along the track, and the balance of the right of way is left to be burnt off later in the fall.

Narrow embankments. Some foremen have a habit of digging holes in the embankment just outside the ends of the track ties when they want a little dirt or ballast to pick up or dress the track. This is all wrong, and can be justified only in case the traffic over the line is so heavy that it is not advisable to attempt to haul earth with a push car. On a mud track if material is wanted for this purpose it should be taken from the nearest cut with the section push car, or if the fill is not very deep the foreman should set his men throwing up dirt from outside the bottom of the original fill. There the necessary material can be procured without injuring the embankment sufficiently to make it likely to wash away, or weakening it as a support for the track. The preference should always be given to material from a cut even when the cost is a little greater. A double purpose is served by removing the surplus which accumulates in the ditches and putting it on the fill to strengthen it. Of course, where track is ballasted with gravel, or other like material, dirt should not be mixed with it, but when only a small quantity of material is needed it can be taken from places where the ballast is the heaviest along the shoulder of the track. Whenever any material is taken from a grade or wasted therein, such places should be leveled off, dressed and finished up in a workmanlike manner. Never leave unsightly holes along the track. Both sides of the embankment should be of the same width outside the ties, if pos-

sible, and grass should be encouraged to grow along the slopes, because it offers the best protection against weeds and washouts. Section foremen should not attempt to raise up track on high, narrow fills in order to surface it. At such places it is always best to pick up and tamp only joints or other low places in the rail, and keep the track in good line until you can get enough dirt or ballast to leave a good shoulder outside the ties after raising up the track to surface.

Haul out material from cuts. Where the distance between cuts is short, and the fill between is high and narrow, section foremen should make good wide ditches in the cuts, haul out the material from the ditches, and distribute it evenly on both sides of the track. This work should be done either early in the spring, or late in the fall of the year, or when the facilities for doing other work are not good.

To remedy too wide an opening at the joints. Track is often laid with too wide an opening at the joints, or has excessive opening at certain points due to rail creeping, and as a result the ends of the rails batter down very quickly and the joint splices often break and tear apart, owing to the contraction of the rails in extremely cold weather. Track foremen who are troubled with this state of affairs should try to remedy it at once in the following manner:

Loosen the bolts in forty or fifty joints and pull out slot spikes as necessary, then, in the middle of this stretch take out one or two of the rails on each side of the track. Have ready to replace the rails that you take out, one or two rails the combined length of which will be six or eight inches greater than that of the rails removed, allowing this length to be a little less than the total amount necessary for closing the joints. Have your men take one loose rail, and bump back the track rails on each side of the opening until it is wide enough to admit of putting in the longer

rails, then bolt and spike the rails to place, dividing the expansion on the other joints afterwards.

Follow out this method at different points along your section wherever you see it is necessary, and you will prevent trouble on account of rails tearing apart in cold weather, endangering trains and increasing your responsibility. The rails will wear much longer, and you can keep a much better surface on the track. Judgment should be exercised in this matter so that the expansion be so distributed that there will be no danger of making the joints too tight for warm weather.

XI

BUILDING FENCES

Building fences.—It is sometimes the duty of section foremen to build fences along the railroad right of way limits; and as there are many foremen who have had no experience in this branch of work, it will not be out of place here to give a good, practical method for performing this duty.

Measure with a tape line from the center of the track to the right of way limits, and set a stake in the ground. This should be the outside face of the fence posts when set. Where the track is straight these measurements need be taken only at distances of ten or fifteen rods, but around a curve they should be taken every fifty or one hundred feet, in order to have the fence conform to the line of the track.

Peel the bark from all fence posts and set their centers sixteen feet apart, when not otherwise ordered, so that boards may be nailed on them if desired. To line the fence and regulate the distance between posts, use a chain or line two hundred feet long for straight track, and one hundred feet, or less, for curve track. Have tin tags at regular distances on your chain, or tie knots in the line to mark where the center of each post hole should come, and when the line is stretched take a spade and remove a little of the sod or top surface of the ground opposite the marks on the line as a guide for the men digging the post holes. The line may then be moved ahead.

Set all posts two and one-half feet in the ground,

and have the men who are digging make marks on their shovels by which to determine the correct depth of the postholes, and thus have all the posts of a uniform height above the ground. A good way to save sighting along straight track is to set a post every ten or fifteen rods with a temporary brace, and stretch one wire of the fence to use as a guide.

When putting on wires, if you are not furnished a wire stretcher, they may be tightened by taking a turn around a lining bar. Stick the point of the bar

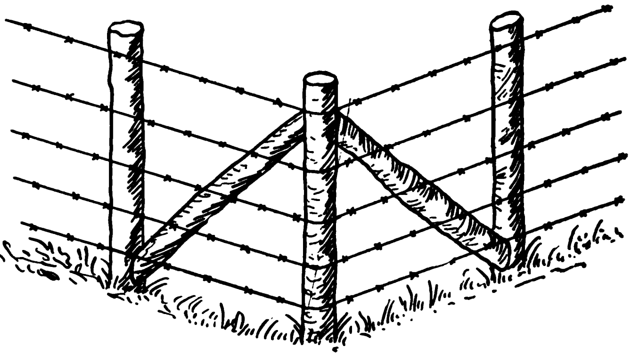


Fig. 34. Fence Corner

in the ground diagonally from you, and pull the top of bar towards you and downward. In this way you can take up the slack.

Always put the wire on the farmer's side of the fence posts. A good brace should be put in at the end of each piece of fence, or at any point where the fence turns an angle, also at gates and cattle guards. See Figs. 34 and 35.

Mortice one end of the brace into the top of the corner post, and the other end into the bottom of the post adjoining, where it enters the ground. Provide

a board with notches cut into it at distances equal to the proper spaces between the wires. The wires may be hung in the notches, and the board will keep them in position while they are being fastened to the posts.

Have the men well organized. Divide a gang of sixteen about as follows: Assign two men to lay out the fence, six to dig post holes, four to set the posts, and four to string the wires and fasten them. Move the men occasionally from parts of the work which are the most advanced to parts which are behind. When crossing creeks or marshy places it is well to

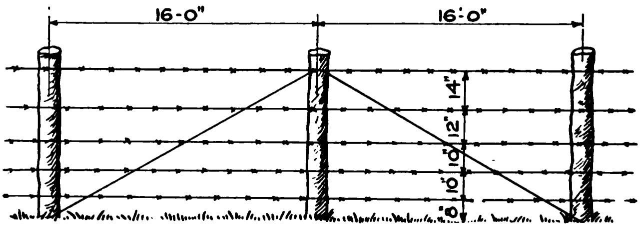


Fig. 35. Standard Fence

turn the fence in at right angles to the end of the bridge and string the wires across on the piles.

Order material as follows: Fence wire, one pound for every single wire panel of sixteen feet; staples, one and three-fourths pounds for each hundred pounds of wire used.

When spacing wires, have the bottom ones the closer together. For instance, for a five-wire fence four and one-half feet high, place bottom wire eight inches above the ground; the second wire ten inches above the first, and the other three wires each twelve inches above the last, or the third wire from the bottom could be spaced ten inches above the second, and the top wire fourteen inches above the fourth. The latter is the best method where it is desirable to fence against

all kinds of stock. The tops of fence posts should not be more than six inches above the top wire of the fence, and all posts when set and tamped solid should be in perfect line and at a uniform height from the ground. When posts are irregular in length, the surplus timber should be sawed off if it amounts to four or more inches, but where the post is only two or three inches too long, the hole may be deepened sufficiently to leave it of the proper height when set.

If a post is two or three inches short fill up the hole sufficiently to bring it to the right height above the ground, but should it be as much as six inches too short, do not use it in the fence except at some place where it would answer for a short brace. To regulate the height of fence post above the ground, have a standard made of the correct length, and nail square across the bottom of it a cross piece two feet long, which will prevent slight inequalities in the surface of the ground from affecting the height when placed beside the post. This standard can also be arranged to regulate the distance between the boards or wires as they are nailed on the fence.

A fence with the top wire or top board four and one-half feet from the ground is a lawful fence in most of the States.

Board fences. In building a board fence, the setting of posts and nailing on of the boards can be done at the same time. Always use the shortest boards to measure from one post to the next one to be set; the longer boards can be sawn to the proper length. Nail the boards on at the outside of the fence. Several men can be nailing on boards at once, ending the boards against those last nailed on the adjoining panel. On straight track, sighting posts can be set at the proper distance from the track, every forty or sixty rods ahead of the men digging the post holes, but on curve track, to make a good fence and have it

in line, every panel post should be measured from the center of the track, and a stake set for it. This is not much of a job, if two men go along the track carrying the tape line stretched from place to place, while a third man sets stakes for the posts. By laying a board against the two panel posts, it lines the place for the middle posts. A bracket, made the proper height from the ground with the projections on it to fit between the boards, making the spaces the correct width, is very handy when building a board fence. It makes a much better fence than when the spacing is done by guess, and saves measuring the spaces.

If board fence is built with the boards meeting on the same side of the post, a batten should be nailed over the joint from the ground to the top of the post.

For a permanent snow fence constructed with posts and boards, the posts may be set about fifteen feet four inches apart, and the ends of the boards can be nailed on opposite sides of each panel post. By this method there is a larger amount of the board available for nailing when putting them up again after being torn, or blown off. It also saves the labor of sawing off the ends of the boards to make them meet square on the post.

The following table will be useful to foremen, when estimating the amount of fencing material required to build a board or wire fence:

Table showing number of posts required.

Distance Between Posts	No. Posts in ¼ Mile.	No. Posts in ½ Mile	No. Posts in 1 Mile.
8 feet.	166	331	661
12 "	111	221	441
16 "	83	166	331
20 "	67	133	265
32 "	42	83	166

Table showing the number of boards 16′ long required.

No. of Boards per Panel.	One-fourth Mile.	One-half Mile.	One Mile.
4 boards	330	660	1320
5 "	412½	825	1650
6 "	495	990	1980
7 "	577½	1155	2310
8 "	660	1320	2640
9 "	742½	1485	2970
10 "	825	1650	3300

One 6 inch sixteen foot board contains eight square feet of lumber. If a lumber estimate is required, multiply the number of boards wanted by eight, and the result is the number of feet board measure when one inch thick, six inches wide and 16 ft. long.

EXAMPLE:—4 boards per panel for ¼ mile of track $= 330 \times 8 = 2{,}640$ feet B. M. of lumber.

Weight of nails.

55, 10 penny, common nails, weigh one pound.
45, 12 penny, common nails, weigh one pound.
30, 10 penny, fence nails, weigh one pound.
28, 12 penny, fence nails, weigh one pound.

To ascertain the amount of nails wanted to build a given length of fence, multiply the number of boards by 6, and divide the result by the number of nails to the pound.

EXAMPLE:—For ¼ mile board fence, 330 boards, 4 per panel; number of nails per board 6; number of fence nails per pound 30: $330 \times 6 = 1980 \div 30 = 66$ lbs.

Weight of fence wire. The average weight of the wire now used by railroads is very close to one pound per rod for one wire, or about 6 lbs. per 100 feet in length. When making estimates for wire fence, about 10 pounds to the mile of fence may be added for tying, splicing, etc. The weight of staples varies according to the size used. Seventy 1½ inch staples to the

pound is the size most commonly used in building railroad fence.

A day's labor for one man at building post and board fence, where the boards meet on the post, six to a panel, and the work of setting the posts is included, is about eight to ten panels of fence complete. When the ends of the boards lap on opposite sides of the post, thirteen to fifteen panels can be constructed by one man in a day. Building a post and wire fence, posts one rod apart, and four strands of wire, a man can construct about fifteen panels in a day; but a great deal depends on the conditions under which the work is performed, the quality of material used, and the quality or general excellence of the work when finished. The results obtained from a man's labor depend, first, on his intelligence; next, on his willingness to work; and lastly, on his physical endurance. These three requisites should always be considered by a foreman when employing men; and when possible he should always choose for his men those who possess all the qualities mentioned.

Woven wire fences. Barbed wire fences are gradually being replaced by woven wire, particularly in the East and in populous districts. They are generally made of steel wire of some meshed pattern, as shown in Fig. 36, and are fastened to posts properly anchored in the ground. The advantages of a woven wire fence are that it can be made to fence against almost any stock, besides which there is less liability to accident than with the barbed wire fence, which is often injurious to stock. The woven wire fence is also readily and economically constructed.

Comparative cost and serviceability of wood and steel fence posts. The majority of American railways employ wood posts for right of way fencing. Usually the kind of wood employed is that which is native to the locality whether or not it is a wood par-

ticularly suitable for such service. These facts, with some discussion of the life and cost of wood fence posts based on the experience of some 44 American railways, are brought out by the report of a special committee of the American Railway Engineering Association in 1913. We summarize a part of this re-

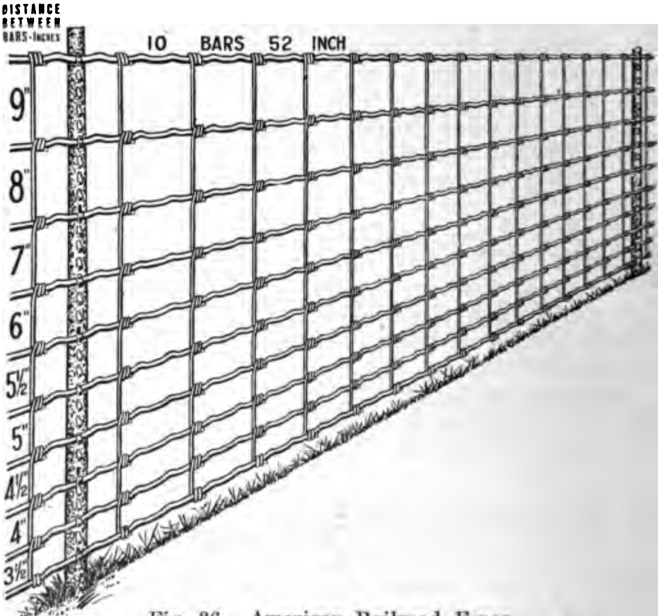


Fig. 36. American Railroad Fence

port and in particular a comparison of steel and wood posts:

"**Wood posts.** From the data collected the life of wood posts of various kinds actually in use is as follows:

	Years.
Red Cedar	7 to 25
Cedar	10 to 30

	Years.
White Cedar	12 to 17
Chestnut	10 to 15
Locust	7 to 20
Yellow Locust	15 to 30
Black Locust	10 to 25
White Oak	7 to 15
Bois D'Arc	12 to 45
Catalpa	10 to 25
Juniper	15
Mulberry	15 to 20

"Doubtless some give little heed to the particular species of the timber that they use, and assume that any species of that genus has about the same life. This is manifestly incorrect as is demonstrated by the oak family. The inferior grades of oak have a life only of from 2 to 4 years, while a good white oak has a life in our northern climates of from 10 to 12 years at least. Certain classes of oak last much longer in their native regions than in other localities to which they are transported for use. This principle applies with equal force to every other class of timber.

"In reviewing the replies of the various roads we find that the consensus of opinion, based upon experience of the users, is that the cost and average life of the different classes of timber are as indicated below:

	Range.	Average.	Years.
Red Cedar	15c to 25c	22c	18
White Cedar	12c to 15c	14c	15
Chestnut	10c to 27c	20c	12
Yellow Locust	20c to 38c	30c	20
Black Locust	15c to 25c	20c	20
White Oak	11c to 40c	20c	10
Bois D'Arc	13c to 17c	15c	25
Catalpa	15c to 25c	20c	15
Juniper	6c to 10c	8c	15
Mulberry	13c to 17c	15c	15

Climatic influences have an important bearing upon this phase of the case, and may lengthen or shorten

the life of a particular kind of wood, dependent upon locality in which used. It is not feasible in most cases to recommend any particular kind of timber for a given territory, as the source of supply may be so distant as to preclude its use economically. It is the prevailing practice to use such timber as is native to the country and thus most easily obtainable.

"It will be observed that the relative cost to life of post ranges from ½ ct. to 2 cts. per year of life, the Bois D'Arc and the Juniper being the cheapest posts, but so rare that a more general use is impossible.

"It was of interest to know to what extent wooden posts were subject to destruction by fire. Replies received indicated that this varied by from 1 per cent to 5 per cent, with the exception of one road which reported a loss of 30 per cent from this cause. We think it fair to assume that the average loss by fire is around 3 per cent.

"**Steel posts.** Only two roads so far as we can learn make mention of having used any metal posts, and then but to a limited extent. In the one case bar iron ¼ x 2 ins. was used and in the other old boiler tubes. We have reason to believe, however, that quite a number of roads, not replying to our circular, are trying out a proprietary metal post. Several styles of steel right-of-way fence posts are on the market. Their exploitation has just begun in the last year or two, and any statement as to their efficiency and economy could be but vague and from the manufacturers' standpoint alone. Greater experience may demonstrate their utility, but thus far we have no data upon them, and can only give some computations from one of the manufacturers, which might be of interest for study from the viewpoint of railroad economy. These figures, while prepared for a certain style of post only, if reliable, will no doubt be equally accurate for any

other style of metal post, built along similar lines, and others are generally so designed. In order that the membership may have the manufacturers' explanation of the merits of the steel post for their further consideration, we give the statement of the case in substance, according to one with whom we have had the matter under discussion:

Steel posts cost	23.03 cents
Cost of setting	1.30 cents
Total	24.33 cents
Estimated life	30 years

"Based upon above figures, steel posts set one rod apart cost 0.81 cents per year.

"**The cost of setting wood posts** is estimated at 5.8 cts. each. The following table is based on wood posts costing from nothing up to 20 cts. each, and is intended to show what the life of wood posts must be at different first costs to be as cheap as the steel posts:

Cost of post. Cents.	Cost of setting. Cents.	Total cost. Cents.	Years it must last to be as cheap as steel. Years.
0	5.8	5.8	7.1
5	5.8	10.8	13.3
8	5.8	13.8	17.
10	5.8	15.8	19.5
12	5.8	17.8	21.9
15	5.8	20.8	25.6
17	5.8	22.8	28.1
18.53	5.8	24.33	30.
20	5.8	25.8	31.8

"The above figures would indicate that wood posts costing 15 cts. would have to have a life of 25.6 years and those costing 20 cts. a life of 31.8 years to be as cheap as steel.

"The first steel posts are said to have been manufactured about 15 years ago at Bloomfield, Ind. Others,

doubtless, of different design unknown to the Committee were manufactured as long ago and perhaps longer, but only during the past twelve years have they been given any serious study with a view to placing them on the market for ordinary right-of-way fencing. Hundreds were taken up and examined to discover signs of rust and deterioration at ground line or elsewhere. They have been in use at Spencer, Worthington, Bloomfield, Ind., and elsewhere in all kinds of soil and under all conditions. The investigations have resulted in placing them on the market during the past year or so.

"To be of economic worth for right-of-way protection, a fence post must possess the following qualities: Durability, practicability, efficiency, and the price must be right. Inquiry develops that one man can set in a day from 15 to 35 wooden line posts. To be conservative, 30 posts per day per man is assumed as the unit of work. Estimating wages at $1.75 per day places the cost of setting a wood post at 5.8 cts. The cost of post is estimated at 12 cts., resulting in an entire outlay of 17.8 cts. Experience demonstrated that three men can readily set from 390 to 640 steel posts per day, or 130 to 213 per man—130 posts per man is taken as the basis of calculation with wages at $1.75 per day. This places the cost for setting a steel post at 1.3 cts., cost of steel post 23.03 cts., plus cost of setting 1.3 cts., resulting in entire outlay, 24.33 cts."

Reinforced concrete posts and signs. Mr. E. F. Robinson, Chief Engineer and Mr. G. H. Stewart, Master Mason of the B. R. & P. Railroad, have furnished some very interesting and valuable data in regard to the manufacture of reinforced signs and posts, which were published in the November, 1914, issue of Railway Engineering and Maintenance of Way, and the June 18, 1915, issue of Railway Age Gazette, from the latter of which the following description is taken:

"This road operates a plant at East Salamanca, N. Y., for the manufacture of these articles. Concrete fence posts are used universally, except in swamps and in places where there is a liability of slides, and since their adoption with the necessary concrete corner posts and braces they have proved very satisfactory. The company plant has manufactured about 15,000 of these posts, 500 concrete mile posts, 600 concrete property line posts and 100 concrete whistle posts. In addition, concrete signal foundations, concrete telephone booths and concrete pipe of various sizes are made at this plant.

"The post and sign plant is housed in a one-story building 90 ft. long and 19 ft. wide with an available floor space of 1,496 sq. ft. Coils of steam pipe are located under the concrete floor and along the sides of the building for heating, and a stationary boiler is provided in one corner to furnish the necessary steam. The cement to be used is stored in one end of the building, securely partitioned off to keep it perfectly dry. The balance of the building is used for the manufacture and curing of the posts and signs, which are stored here until required for use. No special equipment is required in this work other than ordinary concrete mixing tools, as the concrete is mixed by hand except in a few instances when a large amount is to be placed, requiring the use of a mixer to keep a supply on hand. The building is served by tracks along each side, allowing material to be unloaded and the manufactured articles to be loaded with ease.

"The designs of the principal signs and posts are illustrated in the accompanying drawings. The right of way fence posts are of the tapered T-section type 8 ft. long. The flange is 6½ in. wide and 1½ in. thick at the bottom and 4½ in. wide and 1 in. thick at the top, while the stem is 6½ in. deep and 2½ in.

thick at the base, tapering to 2½ in. deep and 1½ in. thick at the top. The reinforcement consists of three pieces of ¼-in. round bars 7 ft. 6 in. long, one bar being placed in each corner of the post. The line wire is attached to these posts by No. 7 soft steel tie wires, wrapped three times around the line wire on each side of the flange of the post. These wires are

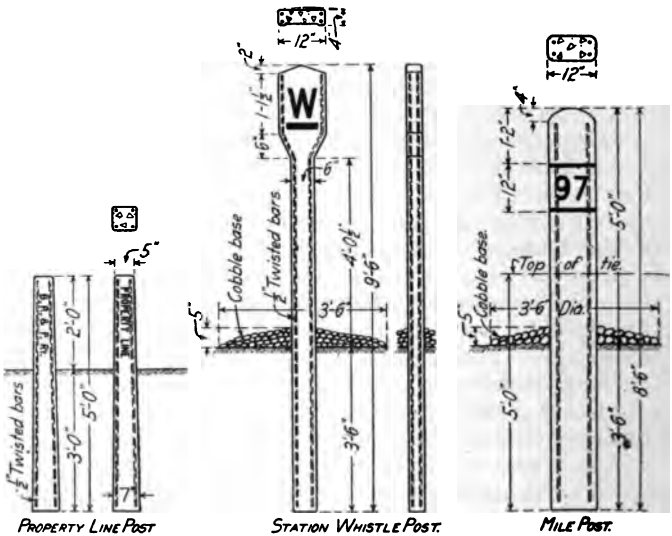


Fig. 37. Details of Concrete Sign Posts

pulled tight to bite into the corners of the posts, thus preventing slipping.

"The corner posts are 6 in. square and 8 ft. long. Notches 1¼ in. deep are cast 6 in. from the top and 3 ft. 6 in. from the bottom of these posts in which the diagonal corner post braces are set, and a slot 2 in. by 4 in. is provided through the post 6 in. from the bottom, into which short anchor bars can be

placed at right angles to the fence line. All corners on these posts are rounded off to a 1/4 in. radius. The reinforcement consists of four 1/4 in. round bars 7 ft. 6 in. long. Five of these posts are placed at each corner on 7 ft. 6 in. centers, thoroughly braced and tied. The braces used with these corner posts are 8 ft. 2 3/4 in. long and 4 in. square, with mitered ends to fit into the notches provided in the corner posts. These braces are also reinforced with four 1/4 in. round bars 7 ft. 6 in. long, and all corners are rounded to a 1/4 in. radius.

"The property line posts, which are set on all property corners, opposite the beginning and the end of all curves and at 1,000 ft. intervals on tangents, are 5 in. square at the top and 7 in. square at the bottom with a length of 5 ft. They are set in the ground 3 ft. On one side of the post are moulded the letters 'B. R. & P. Ry.,' and on the opposite side are the letters 'PROPERTY LINE.' These letters are 2 in. high. The side of the post with the latter lettering is placed toward the main track whenever possible. The post is reinforced with four pieces of 1/2 in. twisted steel bars 4 ft. 6 in. long. The corners of the post are rounded to a 1 in. radius.

"The concrete whistle posts, which are set on the engineer's side of the track 1320 ft. from highway crossings and 7 ft. 6 in. from the near side of the post to gage side of the near rail, are 9 ft. 6 in. long, 6 in. wide and 4 in. thick at the bottom and 12 in. wide and 4 in. thick at the top. The latter width is only maintained for a length of 15 1/2 in. to provide room for the letter 'W.' These posts are set in the ground 3 ft. 6 in. The letter is 7 1/2 in. high, 3/4 in. deep and 1 1/4 in. wide and is placed only on one side of the post, the other side being left blank. This post is reinforced with four pieces of 1/2 in. twisted steel bars, 8 ft. 2 in. long and the corners are rounded to a

¾ in. radius. Station whistle posts are identical with those described except that a line 8 in. long is cast under the letter 'W.' These signs are placed ½ mi. from stations.

"The concrete mile posts are made in two widths, one for one or two figures and one for three figures. The former are 6 in. thick and 12 in. wide and the latter 6 in. thick and 14 in. wide. All are 8 ft. 6 in. long with the upper 4 in. rounded off from the edges to the center. The figures, which are 6 in. high, are

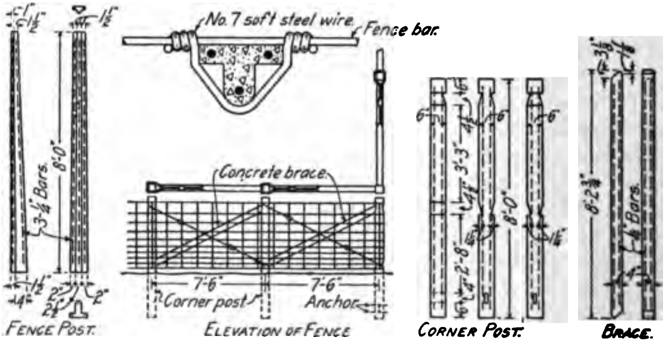


Fig. 38. Details of Line and Corner Fence Posts and Braces

set into the posts between two horizontal lines ½ in. wide placed 14 in. and 26 in., respectively, from the top of the post. Both sides of the post are made the same. The reinforcement consists of four pieces of ½ in. twisted steel bars 8 ft. long and the corners are rounded to a 1 in. radius. These posts are set 3 ft. 6 in. in the ground, and are placed 10 ft. from the center of the post to the gage side of the near rail on the right hand side of the track going south from Buffalo and Rochester. They are used both on the main line and branches.

"A mixture of 1 part cement and 3 parts fine gravel is used in the fence posts, corner posts, and corner post braces, while a 1:2:4 concrete mixture is used in the other cases. The fence posts are cast in gang moulds of 30 each, mounted on trucks. Three of these batteries are used, giving a capacity of 90 posts at one pouring. The other posts and signs described are moulded in wooden forms made of 2 in. surfaced yellow pine, the parts of the moulds being fastened together by hinges and hasps in all cases, except the mile post form, which is clamped in position. In all cases the forms are constructed so that they can be readily removed from the posts after the concrete has set sufficiently, which is about 48 hours. After removing the posts from the forms they are placed on end along timber racks outside of the building for one week to cure properly. During this time they are sprinkled once a day, or as often as necessary, and covered to protect them from the action of the weather. At the end of the week, or when they are strong enough to permit them to be removed, they are corded up in a pile ready for shipment. During the winter they are treated in much the same manner with the exception that they are not taken out of the building until thoroughly cured. The building is kept at an even temperature of 60 deg. After the posts are removed from the forms, the latter are thoroughly cleaned and sparingly coated over with fuel oil to prevent the concrete from sticking to the form when being removed. In the case of the property line post and the whistle post the surface of the concrete is rubbed down to a true, even, uniform surface as soon as the form is removed, using a small briquette and clean water. This briquette is made of 1 part of cement and 2 parts of sand mixed with clean water.

"The letters used on these posts are V shaped and

indented into the concrete, the indentation being painted black in the case of the whistle and mile posts. An advantage of this type of letter is that it eliminates the necessity for restenciling the posts from time to time. In the case of the whistle post the letter 'W' and the line, when it is used, are fastened to the bottom of the forms and the post made face down. The figures and the cross lines on one side of the mile posts are secured to the forms, while the corresponding depressions for the other side of the posts are moulded into the concrete from the exposed surface while it is in the form. The weights and detailed cost of manufacture of these various posts and signs are shown on the accompanying table."

		Cost								
			Material							
			Cement		Aggregate		Reinforcement			
	Weight		Amount		Amount		Amount lin.		Total matl.	Total
	lb.	Labor	Sacks	Cost	cu ft.	Cost	ft.	Cost	cost	cost
Fence post.	87.5	$0.055	0.30	$0.07	0.623	$0.02	22.5	$0.09	$0.18	$0.23
Corner post	285	0.18	0.81	0.19	1.90	0.05	30.0	0.12	0.36	0.54
Corner post brace ..	146	0.15	0.355	0.08	0.875	0.03	30.0	0.12	0.23	0.38
Property line post.	202	0.50	0.29	0.07	1.65	0.05	18.0	0.18	0.30	0.80
Whistle post	410	1.00	0.41	0.09	2.31	0.07	36.66	0.37	0.53	1.53
12-in. mile post ...	560	0.80	0.88	0.20	5.64	0.17	32.00	0.32	0.69	1.49
14-in. mile post ...	690	0.80	1.15	0.26	6.63	0.20	32.00	0.32	0.78	1.58

Method of molding reinforced concrete fence posts. A reinforced concrete post plant having a capacity of 400 posts per day is being successfully operated by the Chicago, Burlington & Quincy R. R. The method of molding fence posts at this plant is outlined in a paper by Mr. L. J. Hotchkiss, Assistant Bridge Engineer, before the National Association of Cement Users. It is stated that while not enough

posts have been made to determine the minimum cost possible, it seems certain that it will be low enough to compete with the price of cedar posts. The reinforced concrete post cannot, however, be so roughly handled. It is in no sense fragile and has ample strength to withstand all fence loads, but some care must be exercised not to cause cracking by throwing about.

Turning now to the manufacture and use of the posts, we abstract from Mr. Hotchkiss' paper as follows: "Figure 39 is a view of the post machine. The measuring apparatus consists of two hoppers, one for gravel and one for cement. A small conveyor underneath the hoppers feeds the two materials in proper proportions into a small elevator boot. From this it is hoisted by a chain of elevator buckets and dropped into the mixer at the top of the machine.

"The mixer is a large shallow bowl with a concave bottom. A number of paddles rotate in this bowl and mix the concrete, water being sprayed on it from a perforated pipe. In the bottom of the mixer is a hole which is closed by a form of gate valve, and through which concrete is discharged into the molds below. Under the mixer is a turntable arrangement which holds four molds at a time. There is also a jolting device so arranged that as each mold is being filled it is alternately raised and dropped through a distance of perhaps an inch. This tamps the concrete effectually and insures a smooth finish.

"Two forms of reinforcement are used. The one which was used last year is made from sheets of No. 24 or No. 26 black iron. The sheets are passed through a machine which cuts out half the reinforcement for a post at each pass. At the same time long slits are cut in the iron and the edges of the slits turned up. Two strips of this material are inserted in the mold to form the reinforcement for one post.

"It has not been altogether satisfactory, however; if the concrete material is a bit too coarse it does not run through the slits readily and the posts are not well filled. The reinforcement also has a tendency to get out of place during filling and is occasionally found to be near the center of the post instead of at the outside.

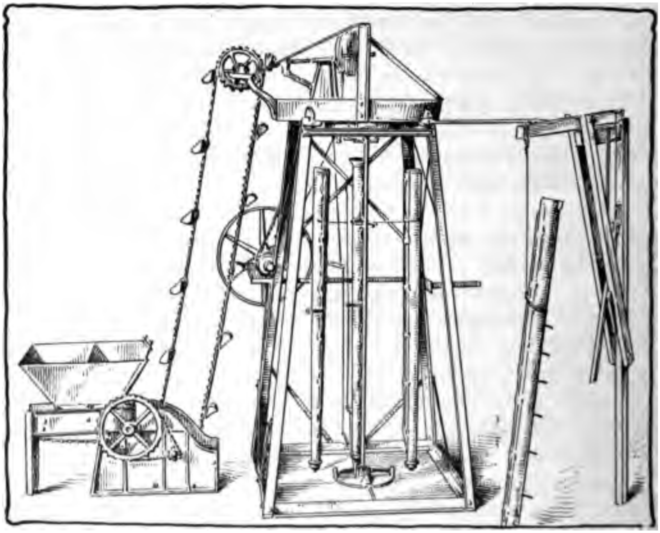


Fig. 39. View of Concrete Post Machine

"Figure 40 shows an improved style of reinforcement now coming into use. It is made entirely of wire, each wire being crimped to insure a bond with the concrete. The material is shipped knocked down, as shown at the left of the photograph, and is quickly made up into the cages shown at the center. The wires may be of such size as needed to give the re-

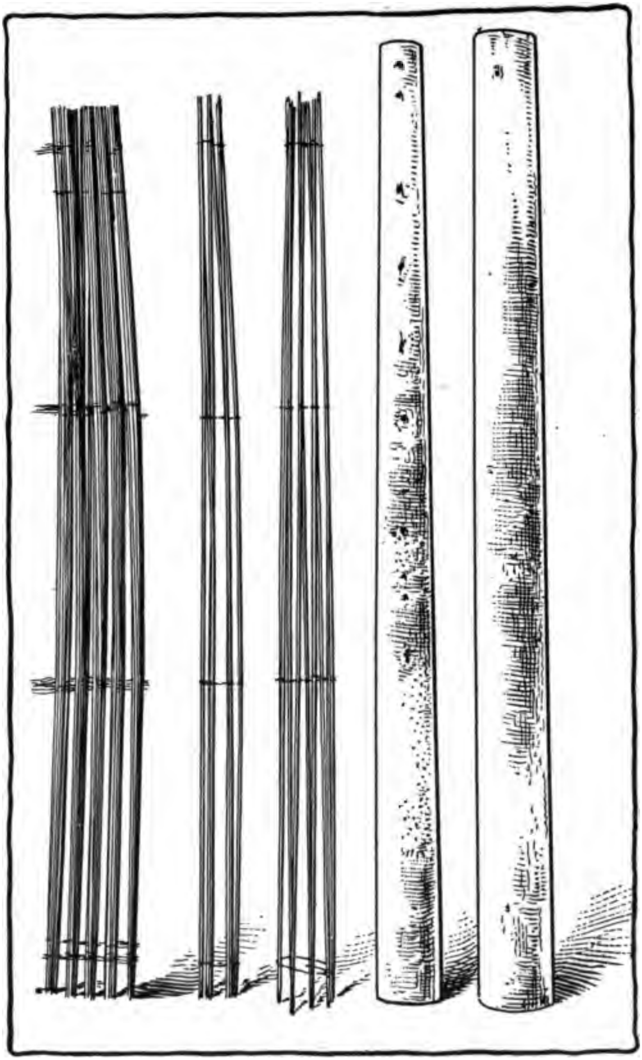


Fig. 40. View of Reinforcement for Concrete Posts, Shown in Bundle for Shipping and Ready for Placing in Mold

quired strength. The concrete flows around this reinforcement without obstruction.

"As the posts are taken out of the machine they are placed on a push car. In cold weather they are stored in the house for a few days before being taken out of doors. In warm weather they are stored indoors or out, as may be most convenient. They are removed from the molds a day or two after being made and stored against the heavy timber racks until ready for shipment or until they are strong enough to be corded up in piles. For a week after being removed from the molds they are thoroughly wet down once a day and in summer they are protected from the sun by tarpaulins.

"The methods of attaching the wire fencing to the concrete posts are illustrated by Figs. 41 and 42.

"Figure 41 illustrates the post and also the method of fastening the wires to the posts. By reference to the cross sections it will be seen that there is a groove in one side of the post and that the holes through the posts are offset, being smaller on the grooved side of the post. These holes are of such a size that a ten penny nail can be pushed through them until the head brings up against the offset. The fence wire is then placed on top of the projecting end of the nail and the latter bent up around the wire until its point is curled back into the groove, thus holding the wire tight against the post. This work is done with a small tool which is shown in successive positions in the upper part of the drawing. This is a very cheap and effective fastening. One difficulty has developed in connection with it, however. The pins with which the holes through the post are made are necessarily all alike. The post is tapered. As a result the small part of the hole through which the shank of the nail passes is longer nearer the bottom of the post than at the top. Consequently the nails at the top stick

out too far and when bent around the fence wire the points strike the bottom of the groove and make it difficult to pull the wire up close to the post. A tapered strip is now attached to the outside of the mold under the heads of the pins. It is of such a thickness that the offset in the holes is a uniform distance from the grooved side of the post and all nails

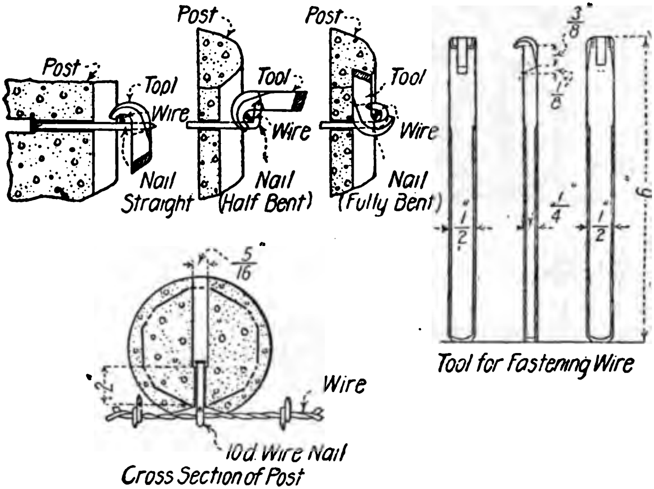


Fig. 41. Method of Fastening Wire on Grooved Posts

project the correct distance to insure proper fastening of the wire.

"Another method of fastening the wires is shown in Fig. 42. It will be seen that the hole through the post is of uniform diameter and a piece of wire with one end doubled back is substituted for the nail. The other end of the wire projects at the back of the post, and by means of the tool shown this is twisted up into a cork screw. The fastening has not yet been

tried out in practice, but its use on an experimental post seems to indicate that it is simple and efficient. It was designed for use with a round post having no groove. As our molds are all grooved, we expect to use it with this type of post.

"The post molding machine is made by the National Concrete Machinery Co., of Madison, Wis.

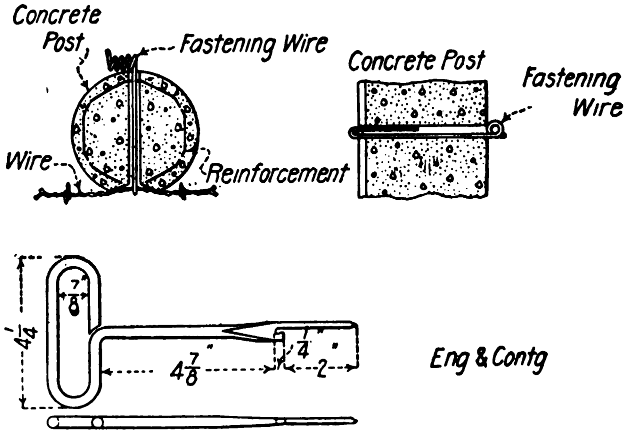


Fig. 42. Method of Fastening Wire on Round Posts

From information furnished by this company we find that the machine requires three men for its operation, one man to shovel in the material, one man to take away posts and put on empty molds, and one to operate the machine. These men, it is stated, should make 40 posts per hour.

"If operated in a sand pit so as to save the cost of moving sand the posts should be produced at a cost of 15 to 20 cts. each, including the five wire reinforcement which costs a fraction less than 7 cts. per post."

XII

GENERAL WINTER WORK

General repairs. There are many kinds of track work which should be done during the winter months, all of which are important and assist materially to lighten and advance the work of the following spring and summer.

In the early part of the winter, when the cold weather has contracted the rails, its effect on the rail joints should be noticed by the foreman; all loose bolts should be tightened up, and broken or cracked joints replaced by good ones.

All open joints should be closed to the proper space and battered rails taken out of the track and replaced by good ones.

Cleaning switches and yard tracks, and flanging out of the main track after snow storms, shimming track, distributing ties for spring work, opening up ditches and culverts, etc., all add to the section foreman's labor, and it requires a man of good judgment and energy to keep all of his work done properly at the right time and place.

If the foreman keeps the loose spikes driven down to place and good gage on his track, he will be surprised at the splendid line which he can have on his track the following summer, and trains will ride over it without that disagreeable side motion of the cars which spoils the line and surface of his track, and is not conducive to the comfort of passengers.

Shimming track is a very important kind of win-

ter work on northern railroads, and should be done with a view to keeping straight track level, smooth and safe, and the proper elevation of the outer rails on curves.

Shims are placed under the track rails to raise up the low places to a good surface. All shims should have holes bored through them for the track spikes. This can be done by boring the holes through a block of straight-grained hard wood, six inches wide by ten inches long, and splitting off the shims as thick as needed. On account of the difficulty of finding such wood in many parts of the country it is best to have this work done in shops where odd pieces of timber may be utilized for making shims, which can be sawed and bored to better advantage there than on the road.

The top surface of the track tie should be adzed off level, especially when there is a groove made by the rail. This is necessary to give the rails a solid foundation, preserve the correct surface, and prevent the shims from breaking. Shims should never be placed lengthwise under the rails, because in that position they increase the height of the rail without widening its base.

Where shims are used, rail braces should be applied against the outside of the rail at every second, third or fourth tie, in proportion to the height of the shims.

High shimming of track is now obsolete and the necessity for it should be guarded against by providing a remedy in the way of improving the ballast, drainage, etc., to remove the cause of heaving track.

All shimmed track should be watched closely, and thinner shims be used to replace the thicker ones as fast as the heaved track settles in the spring. Shims should not be removed from the track until all heaving has gone down. When the rail under which there are shims is higher than the track each side of it by the thickness of the shims, you may remove them as

the heaving has all gone out of the ground. Many foremen have spoiled nice pieces of track by removing the shims and tamping the ties as soon as the frost was out to the bottom of the ties. All good shims, shim spikes and braces should be put away in the tool house every spring and saved for use another year.

Heaved bridges and culverts. Pile bridges need careful watching in the winter season, and whenever they are found heaved up out of surface or line the bridge carpenters should be promptly notified. In some bridges and culverts the piles which have heaved must be cut off, and that part of the bridge or the culvert lowered to correspond with the track on either side of it. Unlike the track in cuts or on fills, some piles which heave up in the winter do not settle back to place again when the frost goes out of the ground, and shims must be put under the caps or stringers to keep the bridges up to surface during the summer. The greatest danger is to be apprehended where the piles in a bridge heave up irregularly, as when only one or two piles heave in a bent, or when the piles heave up in opposite corners of two different bents. This often happens when the piles are driven in deep water, as the ice which freezes to them lifts them up and should, therefore, always be cut away by the trackmen before there is danger of its doing so.

Report amount of snow. Section foremen should ascertain the condition of the track in their charge immediately after every snow storm, or wind storm that is likely to drift snow upon the track, and report the depth and length of snow drifts in all the cuts on their sections. It is of the greatest importance that snow reports be sent promptly by telegraph in order that the officers of the road may be able to make necessary preparations to clear the track.

Snow on side tracks. Section foremen should clear away the snow that has drifted upon side tracks as

soon as possible after a storm, and the snow on switches and in frogs and guard rails should be shoveled off as necessary. This work should never be delayed as trainmen may need to use the switches at any time.

Snow in cuts. During the winter months when snow falls or is drifted into cuts to a depth of two or more feet, section foremen should take their men just as soon as possible after the storm and remove from the track sufficient snow at the ends of all drifts to leave a clean flange and a clear face of snow, at least eighteen inches deep, at both the approach and run-out ends of the drift. It is a fact that a great many engines, when bucking snow, run off the track when coming out of, or running into a snow drift. This is generally caused by hard snow or ice in the flanges. On being suddenly relieved of the resistance of the snow the truck wheels sometimes mount the rail on a hard flange-way and are derailed.

Flanging track. Whenever the track becomes full of snow in the winter it is necessary to flange it out. Most roads now have flanging machines for this purpose. These devices may be divided into two classes, those directly attached to the locomotive and those built into a special car. The former class is obviously the best and most economical since it does not necessarily require a special train for the purpose of flanging a division, as in the latter class. The Priest flanger has proved to be a very serviceable device for removing snow. On this device there is nothing that can break except the knives, which may suffer if they strike a metallic obstruction like a guard rail, but can be readily replaced. If the engineer is careful to raise the mechanism every time he approaches such an obstruction, the knives will last until they wear out. When the flanger is used the only hand flanging that the trackmen will have to do will be around frogs and

switches and highway crossings, where the knives of the flangers had to be raised. The Priest flanger has thoroughly flanged track at the head of heavy freight trains cutting through twelve inches of fairly hard snow, the trains making nearly schedule time.

Some roads have a proportion of the heaviest locomotives in freight service equipped with pilot plows as soon as winter sets in and leave them on until all danger from snow is past. These engines, moving over the line in regular service, keep the track clear down to within a few inches of the rail. If conditions are such as to warrant it one of the engines so equipped can be started over the road light to open up the track and make fairly good wheeling for following trains. A helper engine can be added if necessary.

Opening ditches and culverts. On roads where snow lies on the ground during the winter months, section foremen should open up all ditches, culverts, and other waterways which pass along or under the track. Culverts, which are apt to be covered with snow in the winter, can easily be located when the thaw comes, if a long stake is driven close to the mouth of each culvert early in the fall of the year before any snow falls on the ground.

In cuts that are full of snow on each side of the track, leaving only room enough for trains to pass through, a ditch should be made in the snow about six feet from the rail on each side of the track so that when the water begins to run it will not injure the track by running over it.

Protect your men. When the line becomes blockaded and before the snow bucking gang arrives, trackmen should clean the snow from every alternate rail in long, deep cuts where it would be likely to stick the snow plow. A look out should be kept so that the men in the pits are not caught by the unexpected arrival of the train. If the amount of snow in a cut is not

sufficient to stall the type of snow plow used it will be a waste of time to do this work. By cleaning the snow from alternate rails, as mentioned, and with two engines coupled together doing the "bucking," one engine will always have a clean rail under it and the resistance of the snow will not be great enough to stop the plow, no matter how long the cut may be.

Snow walls. If you have any snow fences for protection along the cuts on your section, watch them closely, and whenever you find a fence which has been drifted full of snow, or nearly so, build with blocks of snow, taken from the inside face of the drift, a wall four feet high along the top of the highest part of the drift. As long as the weather remains cool a wall built of blocks of snow will give as good protection to a cut as would the same amount of ordinary snow fence. Make snow walls strong and thick, and increase their height on the worst cuts in proportion to the force of men that can be spared to do the work, and use double lines of snow wall fifty feet apart where necessary.

Snow fences. On the majority of northern railroads the amount of snow-fall during the winter months is not so great as to require the building of snow sheds, but to protect the cuts along the track from filling with snow, fences are built along the tops of the cuts at a sufficient distance from the track to catch the snow when it is drifted and prevent it from being blown into the cuts and blocking the track. The efficiency of a snow fence as a protection against snow depends on its strength, durability, height, how far it is from the track and the manner in which it is arranged along the tops of the cuts.

Snow fence is not needed on cuts where heavy timber or underbrush grows close along each side of the track, as the only snow in such cuts falls directly upon the track. But where the ground is level for some distance from the track, or on a gently rolling prairie,

cuts are likely to fill up with snow if not properly fenced. Snow fences should be set up at such a distance from the track that the edge of the snow drift forming inside of them will not reach within thirty feet of the track when the fence is drifted full. A good rule is to set the fence about eleven or twelve feet from the track for each foot in height of fence; the height of snow fence regulating its distance from the track. If a snow fence is set too far from the track for its height, the wind, after passing over the top of the fence, soon strikes the ground on the inside of the fence and gathers all the snow before it into the cut, and part of the snow which blows over the fence is also carried to the track.

Storms from the northwest, north and northeast are the most prevalent throughout the Northwest, and as a general rule the north sides of railroads running east and west and the west sides of roads running north and south need the most protection from snow. Where two snow fences are put up on one side of the track they should run parallel with each other. Unless a very large quantity of snow is drifted the outside fence will hold it all.

Very good results have been attained by setting out the snow fence next to the track in the following manner: If the fence is of ordinary height, set it up seventy-five feet from the nearest track rail. Enough of the snow fence should run parallel with the track to reach the full length of the cut and no more. After this part of the fence is up, turn a wing on each end of it, approaching the track gradually until the extreme end of each wing extends 100 feet beyond the end of the cut, at a distance of about fifty or sixty feet from the track rail.

When a cut ends abruptly on the beginning of a high fill, the wing on that end of the snow fence should be turned in toward the track before the end

of the cut is reached, or at least soon enough to protect the cut from a quartering storm. A snow fence built parallel with the track and without a wing on the end of it, is of very little use when a storm blows nearly parallel with the track, as much of the snow on the inside of the fence is apt to be blown into the cut. New ties which are received for repairs to track the following spring can be distributed and used advantageously to make a temporary snow fence on cuts where needed. The ties may be laid along in line with their ends lapping each other about one foot. Slats or pieces of board can then be put across the ends of the ties where they lap and a new line of ties laid along on top of them until the snow fence is of the proper height.

XIII

BUCKING SNOW

General remarks. No one is so well qualified to buck snow as he who has had some experience at it, and no man should be trusted with full charge of a snow plow outfit unless he certainly understands the best methods to be employed in opening up the road for traffic after a blockade. The man in charge of a snow plow outfit should be informed of the exact condition of the road, the depth of snow, the lengths of drifts, and their location as nearly as possible, before starting out. Another engine and car, with a conductor, train crew and shoveling gang, should follow close behind the snow plow during the daytime, and should be coupled in behind the plow when running after dark.

The second engine should be used as a helper in striking deep snow, and to pull out the plow engine whenever it is stuck fast in a snowdrift. All cars attached to the helper engine should be left behind on the clear track when both engines run together to buck a drift of snow. Never allow two engines to buck snow with a caboose or other car between them, as either arrangement endangers the lives of the men on the train. There is no necessity for using two engines behind the snow plow to buck snow which one engine can throw out. If the snow is not too hard one good heavy engine and plow will clear the track of a snow drift three to five feet deep, and from five to eight hundred feet in length, at one run.

Two good locomotives coupled together behind the plow, if managed properly, will remove any snow which it is advisable to buck. Snow drifts which are higher than the plow cannot be cleared from the track successfully without first shoveling the snow off the top of the drifts. They should be opened wide enough to enable the plow to throw out of the cut the snow left in it. When the snow is reported hard those in charge of snow plow outfits should be very careful to have their engines and plow in as perfect condition as possible. They should run no risk; every snow drift should be examined before running into it, and each end should be shovelled out enough to leave a clean flangeway and a face that will let the plow enter under the snow. The tendency of hard snow is to lift the plow up over the top of the drift and throw the engine off the track. Whenever the ends of the drifts are not faced as before mentioned there is always great danger when entering or leaving short, shallow drifts of hard snow; while on the contrary there is little or no danger in plowing soft, deep snow at high speed.

The engines with a snow plow outfit should always take on water and fuel to their full capacity at every point on the road where a supply can be obtained. When it is at all probable that progress will be slow on account of hard or deep snow, a car loaded with coal should be taken along by the helper engine.

Length of run. In plowing snow the length of run and the speed of the engine should always be in proportion to the depth and length of the snow drifts. If the drifts are deep and long, and likely to stick the plow, a good long run should be taken on the clear track, so that the plow engine may acquire good speed before striking the drift.

The engineer of the snow plow engine should sound the whistle frequently when approaching a cut, so that

section men, if working there, would be warned in time to get out of the cut. When the snow plow is making repeated runs for a big snow drift, the signal to come ahead should never be given until all the snow shovelers have left the cut. It is very difficult for men to climb out of a cut where the snow is deep, and many accidents have occurred where approaching trains have failed to warn the men in time, or where the men have neglected to look out for the danger until it was too late.

Preparing drifts. If necessary, very hard snow should be broken up by the men and the crust thrown out before striking it with a snow plow. The shock felt when striking a hard drift is sometimes very great, and often damages the machinery or knocks the plow from the track. The force of the concussion may be materially lessened by having the men clean a good flangeway, and then shovel out of the face and top of the drift enough snow to make a gradual incline of about one foot to the rod. Besides reducing the force of the shock the above method of preparing a hard snow drift enables the snow plow to open it for a much greater distance at a run.

Snow plowing with a plow car ahead of a locomotive has been supplanted to a considerable extent by the improved rotary snow plows, especially when cuts are deep and long and the snow is hard.

A hot blast gasoline torch for thawing interlocking connections is made by the Turner Brass Works of Sycamore, Ill.

The tank of the torch is made of heavy gage brass tubing 2 ins. in diameter and 5 ft. long. There is a burner at one end of the tube and a gasoline valve and pressure pump at the opposite end. There is also a controlling valve inside the tube which regulates and controls the flow of the gasoline. The long tube holds the gasoline supplied to the burner. The size of the

blast flame is regulated by the control valve. The torch and flame can be pointed in any direction desired.

The tank has a capacity of three quarts. The consumption of gasoline is one quart per hour when the flame is 2 ins. in diameter at the burner and 12 ins. long. The length of the tool over all is 5 ft. 9 ins., and it weighs about 8 lbs. The tool operates on the same principle as the ordinary gasoline blow torch. It gives a heat production equal in amount to that of six ordinary blow torches.

For removing snow and ice from railway tracks, especially around the movable portions of the track actuated by interlocking plants, these torches will prove very useful and economical. Following a recent severe sleet and rain storm in Chicago and vicinity, which froze up the movable parts of railway tracks, a single torch of the character here described was sufficient to take care of the large number of switches in the Chicago transfer yard of the Chicago Great Western R. R. The work formerly done by five or six men by old methods was, in this case, performed by one man with one of these torches.

The torch is also well adapted to thawing frozen water pipes and hydrants. It is also useful in melting the lead out of bell and spigot joints on water mains where a section or two of pipe must be removed for any cause. The device possesses other obvious fields of application, particularly on construction operations in cold weather.

XIV

LAYING OUT CURVES

Geometrical properties. Curves are spoken of as being of a certain degree or radius. The radii of curves are inversely proportional to the degrees of their curvature. The radius corresponding to any degree may be found approximately by dividing 5730 (the radius of a 1 degree curve) by the degree of curve.

Hence the radius of a 5 degree curve $= 5730 \div 5 = 1146$.

This rule is very close for radii of not less than 500 feet.

The middle ordinate of a chord is the perpendicular distance from the middle of the chord to the curve; thus M N, Fig. 43, is the middle ordinate of the chord C D.

The middle ordinate may be found, approximately, by dividing the square of the chord by eight times the radius.

The chord deflection (in feet)of a 100 foot chord may be ascertained (exactly) by dividing 10,000 by the radius in feet. The tangent deflection is one half the chord deflection.

To lay out a curve by offsets. In Fig. 43 the line H C subtends the angle formed by the tangent A B produced to H, with the chord B C, and is called the tangent deflection. The line I D, which subtends the angle formed by the chord B C produced to I, with the chord C D, is called the chord deflection. The

RADII, ORDINATES AND DEFLECTIONS FOR 100 FEET CHORDS.

Deg.		Rad.	Mid. Ord.		Tang. Deflec.		Chord Deflec.	
D	M.	FT.	FT.	IN.	FT.	IN.	FT.	IN.
0	10	34377	0	0 7/16	0	1¾	0	3½
	20	17189	0	0⅞	0	3½	0	7
	30	11459	0	1 5/16	0	5¼	0	10½
	40	8594	0	1¾	0	7	1	2
	50	6875	0	2 3/16	0	8¾	1	5 7/16
1		5730	0	2⅝	0	10½	1	8 15/16
	10	4911	0	3 1/16	1	0 9/16	2	0 7/16
	20	4297	0	3½	1	2	2	3 15/16
	30	3820	0	3 15/16	1	3 11/16	2	7 7/16
	40	3438	0	4⅜	1	5 7/16	2	10⅞
	50	3125	0	4 13/16	1	7 3/16	3	2⅜
2		2865	0	5¼	1	8 15/16	3	5⅞
	10	2645	0	5 11/16	1	10 11/16	3	9⅜
	20	2456	0	6⅛	2	0 7/16	4	0⅞
	30	2292	0	6 9/16	2	2 3/16	4	4⅜
	40	2149	0	7	2	3 15/16	4	7⅞
	50	2022	0	7 7/16	2	5 11/16	4	11 5/16
3		1910	0	7⅞	2	7 7/16	5	2 13/16
	10	1810	0	8 5/16	2	9 3/16	5	6 5/16
	20	1719	0	8¾	2	10⅞	5	9 13/16
	30	1637	0	9 3/16	3	0 11/16	6	1 5/16
	40	1563	0	9⅝	3	2⅜	6	4¾
	50	1495	0	10 1/16	3	4⅛	6	8¼
4		1433	0	10½	3	5⅞	6	11¾
	10	1375	0	10⅞	3	7⅝	7	3¼
	20	1322	0	11 5/16	3	9⅜	7	6¾
	30	1274	0	11 13/16	3	11⅛	7	10¼
	40	1228	1	0 3/16	4	0⅞	8	1¾
	50	1186	1	0 11/16	4	2⅝	8	5 3/16
5		1146	1	1⅛	4	4⅜	8	8 11/16
	10	1109	1	1½	4	6 1/16	9	0 3/16
	20	1075	1	2	4	7 13/16	9	3 11/16
	30	1042	1	2⅜	4	9 9/16	9	7⅛
	40	1012	1	2⅞	4	11 5/16	9	10⅝
	50	983	1	3¼	5	1 1/16	10	2 3/16
6		955	1	3 11/16	5	2 15/16	10	5⅝
	10	930	1	4⅛	5	4 9/16	10	9⅛
	20	905	1	4 9/16	5	6 5/16	11	0 9/16
	30	882	1	5	5	8	11	4
	40	860	1	5 7/16	5	9¾	11	7½
	50	839	1	5⅞	5	11½	11	11

RADII, ORDINATES AND DEFLECTIONS FOR 100 FEET CHORDS—Continued.

Deg.		Rad.	Mid. Ord.		Tang. Deflec.		Chord Deflec.	
D.	M.	FT.	FT.	IN.	FT.	IN.	FT.	IN.
7		819	1	6 5/16	6	1 1/4	12	2 1/2
	10	800	1	6 3/4	6	3	12	6
	20	782	1	7 3/16	6	4 3/4	12	9 1/2
	30	765	1	7 5/8	6	6 1/2	13	1
	40	748	1	8 1/16	6	8 1/4	13	4 7/16
	50	732	1	8 1/2	6	10	13	8
8		717	1	8 15/16	6	11 3/4	13	11 7/16
	10	702	1	9 3/8	7	1 7/16	14	2 7/8
	20	688	1	9 13/16	7	3 3/16	14	6 3/8
	30	675	1	10 1/4	7	4 15/16	14	9 7/8
	40	662	1	10 11/16	7	6 11/16	15	1 3/8
	50	649	1	11 1/8	7	8 7/16	15	4 13/16
9		637	1	11 9/16	7	10 1/8	15	8 5/16
	10	625	2	0	7	11 7/8	15	11 13/16
	20	615	2	0 7/16	8	1 5/8	16	3 1/4
	30	604	2	0 7/8	8	3 3/8	16	6 3/4
	40	593	2	1 5/16	8	5 1/8	16	10 1/4
	50	583	2	1 3/4	8	6 7/8	17	1 11/16
10		574	2	2 3/16	8	8 5/8	17	5 3/16
	30	546	2	3 1/2	9	1 13/16	18	3 5/8
11		522	2	4 13/16	9	7	19	2
	30	499	2	6 1/8	10	0 1/4	20	0 1/2
12		478	2	7 7/16	10	5 7/16	20	10 7/8
	30	459	2	8 3/4	10	10 5/8	21	9 1/4
13		442	2	10 1/16	11	3 7/8	22	7 11/16
	30	425	2	11 3/8	11	9 1/16	23	6 1/8
14		410	3	0 11/16	12	2 1/4	24	4 1/2
	30	396	3	2	12	7 7/16	25	2 7/8
15		383	3	3 5/16	13	0 5/8	26	1 1/4
	30	371	3	4 5/8	13	5 13/16	26	11 5/8
16		359	3	5 15/16	13	11	27	10
	30	348	3	7 1/4	14	4 3/16	28	8 3/8
17		338	3	8 5/8	14	9 3/8	29	6 3/4
18		320	3	11 1/4	15	7 3/4	31	3 7/16
19		303	4	1 7/8	16	6 1/16	33	0 1/8
20		288	4	4 1/2	17	4 3/8	34	8 3/4
21		274	4	7 1/8	18	2 11/16	36	5 3/8
22		262	4	9 3/4	19	1	38	2
23		251	5	0 7/16	19	11 1/4	39	10 1/2
24		240	5	3 1/16	20	9 1/2	41	7
25		231	5	5 3/4	21	7 3/4	43	3 1/2

number of degrees in the angle I C D, expresses the degree of the curve when the chord is 100 ft.

In the table of Radii, ordinates for a curve containing odd minutes can be readily calculated by simple proportion. Having these respective distances, any intelligent foreman can trace a curve on the ground with tolerable accuracy, especially where the ground is favorable.

Suppose it be required to lay out in this manner, a four degree curve:—First, find from the table the tangent deflection, H C, corresponding to a four-degree curve, viz, 3 feet 5⅞ inches, and also the chord

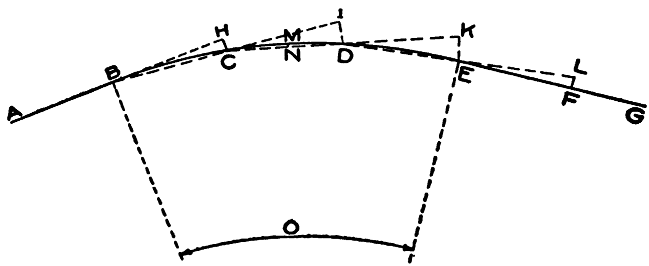


Fig. 43. Elements of Railroad Curve

deflection, I D, or K E, 6 feet 11¾ inches. Then from the starting point, B, and in line with A B, measure B H, equal to 100 feet, and mark the point H. Swing the tape around toward B C, keeping the end at B fixed, at the same time measure from the point H the tangent deflection 3 feet 5⅞ inches, and place a stake at C for the first point on the curve. Then make C I equal to 100 feet, putting a peg at I, in line with those at B and C. Swing the tape around until I D is equal to the chord deflection, 6 feet 11¾ inches. Place a stake at D for the second point on the curve.

In the same manner continue the chord deflection until the end of the curve is reached at E.

In order to pass from the curve at E to the next tangent, E G, make E L equal to 100 feet, and put in a peg at L in line with those at D and E. Swing the tape around until F L is equal to the tangent deflection. Then will a line passing through E and F be tangent to the curve at E.

Difference in length between the inner and outer rails of a curve. There are three different methods for finding this difference: 1st. The difference in length may be taken at $1\frac{1}{32}$ inches, per degree of curve per 100 feet.

EXAMPLE:—To find the difference in length between the inner and outer rails on 600 ft. of 10 degree curve. Here $10 \times 1\frac{1}{32} \times 6 = 5.154$ ft. $=$ 5 ft. $1\frac{7}{8}$ inches.

2d. Divide the distance from center to center of the rails (ordinarily 4 feet 11 inches, or 4.9167 feet) by the radius of the curve, and multiply the result by the length of the curve in feet.

EXAMPLE:—Taking the same example 600 ft. of 10 deg. curve, $(4.9167 \div 573.7) \times 600 = 5.142$ ft. $=$ 5 ft. $1\frac{3}{4}$ inches.

3d. Multiply the excess for a whole circumference, by the total number of degrees in the curve, and divide the product by 360. The excess for the whole circumference, no matter what the degree of curve, is equal to twice the distance between rail centers multiplied by 3.1416.

Where the distance between rail centers is 4 feet 11 inches, the excess for a whole circle is 30.892 feet.

EXAMPLE:—Taking the same example 600 feet of 10 deg. curve $(30.892 \times 600) \div 360 = 5.148$ ft. $=$ 5 ft. $1\frac{3}{4}$ inches.

For the easier curves that are laid to exact gage the first method is the simplest. On sharper curves, where the gage is widened, or for narrow gage lines, use the second method, or prepare a table by the third method.

XV

ELEVATION OF CURVES

General remarks. The rails on straight track are kept level so that the weight of trains may be borne equally by both rails and to insure easy riding for trains. If one rail were lower than the other it would receive more than half the load, which would cause the ends of the ties on that side to sink still lower in the roadbed and then, because resting on an incline, the track would be moved to the lower side and out of line by the swinging of trains. The same is true, of course, if the weight on one rail is greater than the other; the line and surface of the track will soon show kinks and swings.

Centrifugal force. With a train standing still on a curve the rails must be level for each to bear half the weight, but when the train begins to move some extra weight will be thrown on the outer rail by the centrifugal force, which develops with the speed of the train. This centrifugal force is the resistance offered by all moving bodies to anything which may be interposed to change their course from a straight line, and may be illustrated by throwing a stone at a board set at an angle of say 45 degrees. If the stone misses the board it will move onward in a straight line until forced to the ground by the attraction of gravity. But if it strikes the board it is deflected from its course and the dent made in the board shows in a way the amount of force offered by the stone in resisting the effort of the board to change its course to that extent. On rail-

roads, the curves are made long and as easy as possible, so that the destructive force shown by the impact of the stone against the board may be considerably reduced by distributing it over several hundred feet of track.

Centripetal force. This lengthening of the curve being insufficient, the outer rail of the curve is elevated so that the centripetal force set up thereby may counteract the remaining centrifugal force. The centripetal force in this case is simply the force of gravity, which tends to tip the leaning cars over toward the inside of the curve. Now, when the curve is elevated so that these two forces exactly balance each other, the weight of a moving train will be supported equally by the two rails. If the elevation of a curve is just right for a speed of forty miles per hour, it is evident that trains running sixty miles per hour will press laterally against the outer rail, and if this pressure be great it may throw the track out of line or spread the rails. On the other hand, with trains running only twenty miles per hour the weight would be greatest on the lower rail, and while it would tend to depress the rail still more, and perhaps develop swings when the ballast is weak, it would not spread the track.

Effect of speed on elevation. The elevation necessary on curves depends on the speed and on the degree of curve. For instance, if a four-degree curve requires 7 inch elevation for speed of fifty miles per hour, for a speed of twenty-five miles per hour it would require not $3\frac{1}{2}$ inches but only $1\frac{3}{4}$ inches to balance the weight of trains. This may be illustrated by Fig. 44.

A weight B is suspended from a rigid support S by a cord A. By giving the weight a circular motion it will describe a circle C around a center E, and the angle of the cord A B will show what elevation would

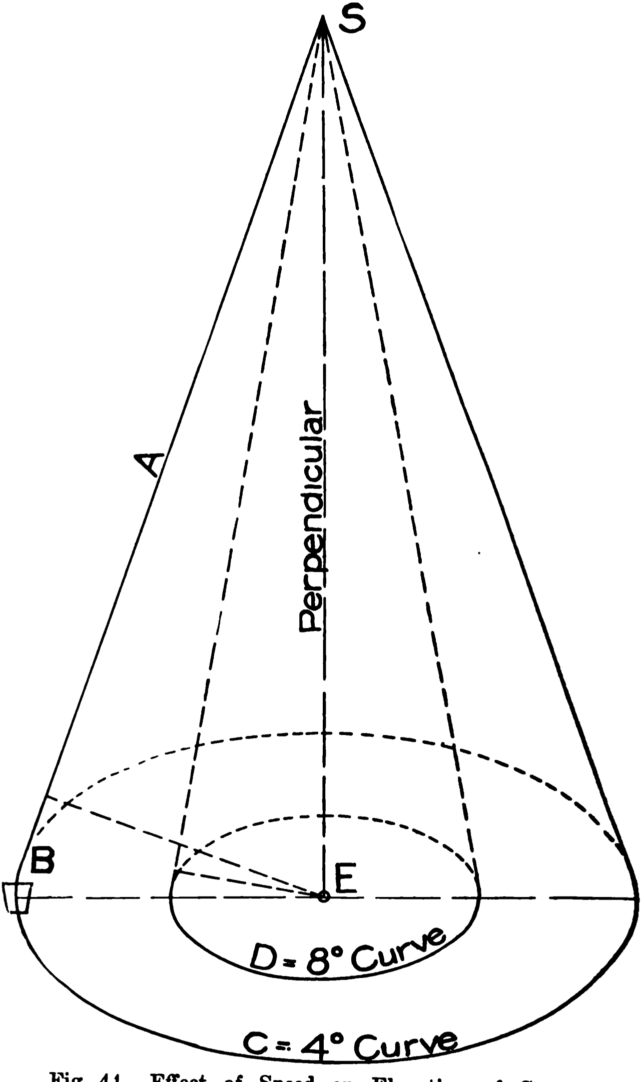


Fig. 44. Effect of Speed on Elevation of Curves

be required if the circle C were a track in order to distribute the weight of B if it were a car bearing equally on both rails at a given speed; that is, the level of the rails should be at right angles to the line S B to give the curve the proper elevation for the rate of speed at which the weight B moves around the circle. Suppose that circle C represents a four-degree curve and the inner circle D, with but half the radius of C, represents an eight-degree curve. Now, if the weight B moves around the outer, or four-degree, curve, in say four seconds, it will revolve in continually decreasing circles, but always in the same period of time, and will move around the inner circle, or the eight-degree curve, in four seconds also. But the inner circle being but one-half the circumference of the outer, it follows that the speed of the weight is reduced one-half. The position of the dotted line shows that the angle of the cord from the perpendicular has been reduced one-half also, and this indicates that the elevation of curve D should be one-half that of curve C. Now suppose weight B is a car traveling around four-degree curve C at fifty miles per hour, and the angle of the cord S B shows that an elevation of 7 inches is necessary to bring the level of the rails to a right angle with the cord, then when the car moves around eight-degree D it is going at the rate of twenty-five miles per hour, and the elevation necessary, as shown by dotted line, is half that of the outer curve, or 3½ inches; and, if an eight-degree curve should be elevated 3½ inches for a speed of twenty-five miles per hour, a four-degree curve should be elevated only 1¾ inch for the same speed, as previously stated.

It requires more than a passing thought to understand the two elements that must be considered in calculating elevation. One is increase of speed and the other increase of curvature. In one case elevation should increase in exact proportion to the increase of

curvature where the rate of speed is the same. In the other, if the speed is increased say two times, the elevation should be increased four times where the curvature is the same. This explains the reason for giving such light elevation in yards and other places where the speed does not exceed twenty-five miles per hour, in proportion to the elevation given main tracks when the speed is fifty miles per hour. In fact, some roads, while giving liberal elevation on main line curves, allow little or none in yards.

How to calculate the elevation. While the theory of elevation is easily understood, the application in practice brings in the speed factor, which is more or less uncertain, as trains will run at different speed. The practice is to elevate for the highest speed at which trains are to be run over the particular piece of track, and if the curvature requires an elevation beyond the prescribed maximum (some roads specify 6" and others 8") the only alternative is to reduce the speed of the fastest trains.

The correct rule, deduced from Mechanics, is

$$E = \frac{v^2 g}{32.16\ R}$$

the result being in feet or fractions of a foot. V^2 means the square of the velocity in feet per second. This should be multiplied by g, the gage, which in this case is the distance between points supporting the wheels, or from the center of one rail head to the center of the other, say 5 feet, instead of 4′ 8½″, and the result, divided by the product of 32.16, which represents the intensity of force of gravity, multiplied by R, or radius of the curve in feet, will be the elevation expressed in feet, or fraction of a foot. That the rule may be understood by all, the following examples are made as plain as possible.

Example:—What elevation should be given a four-

degree curve for a speed of sixty miles per hour? In this case the velocity is 88 feet per second and the radius of this curve 1433 feet; therefore, 88 is multiplied by 88, and the result by the gage 5 feet $= 38720$; this is divided by 32.16 multiplied by radius $1433 = 46085$

$$\frac{38720}{46085} \text{ ft.} = 10 \text{ inches.}$$

What elevation should be given a four-degree curve for a speed of thirty miles per hour, velocity 44 feet per second?

$$\frac{44 \times 44 \times 5 = 9680}{32.16 \times 1433 = 46085} \text{ ft.} = 2\tfrac{1}{2} \text{ inches.}$$

In this example the result follows closely the practice of trackmen who give ½ inch per degree for a speed of thirty miles per hour, but in the former example the result, 10 inches, for a four-degree curve for a speed of sixty miles per hour is more than it is good practice to put in the track not only because the curve resistance for the slower trains and the wear on the low rail would be excessive, but because the center of gravity of any cars or locomotives that happen to stop on the track would be too far in. Consequently, if the maximum elevation allowed is eight inches the speed around the four-degree curve should be reduced to about fifty-two miles per hour, and if the maximum elevation permitted is six inches the speed should be reduced to forty-seven miles per hour.

Curving rails. Bend or curve the rail through its entire length until the middle ordinate of the rail equals as many quarter inches as there are degrees in the curve for which you are preparing it. To ascertain this, stretch a string between the extreme points of the rail on the gage side and measure the distance from the center of the string to the gage side of the

rail at its center. For foremen who have not had much practice in curving rails it is best to also measure the distance from the string to the rail at the quarters, seven and one-half feet from the end of a 30-foot rail, and this distance should be three-quarters of what it is at the center of the rail. By measurements taken at the quarters it is generally easy to detect a kink in the rail, which should always be taken out. Rails which have a true curve will hold their place in the track ready for spiking. The more accurate the curve of rails, the less the amount of lining that the track will need afterward.

Table of elevation of outer rail on curves in inches.

	Speed in Miles per Hour									
Degree of Curve	15 miles	20 miles	25 miles	30 miles	35 miles	40 miles	45 miles	50 miles	55 miles	60 miles
1	⅛	¼	⅜	⅝	¾	1⅛	1⅜	1⅝	2	2⅜
2	⅜	½	⅞	1⅛	1⅝	2⅛	2⅝	3¼	4	4¾
3	½	¾	1¼	1¾	2⅜	3⅛	4	4⅞	6	7⅛
4	⅝	1	1⅝	2⅜	3¼	4¼	5⅜	6⅝	8	
5	¾	1¼	2	3	4	5¼	6⅝	8¼		
6	1	1⅝	2½	3½	4⅞	6¼	8			
7	1⅛	1⅞	2⅞	4⅛	5⅝	7⅜				
8	1¼	2⅛	3¼	4¾	6½					
9	1⅜	2⅜	3¾	5⅜	7¼					
10	1½	2⅝	4⅛	5⅞	8⅛					
11	1¾	2⅞	4½	6½						
12	1⅞	3⅛	4⅞	7⅛						

NOTE—The figures above the heavy black line are the ones ordinarily used in practice.

Rail benders. There are two general types of rail benders, one operated by the section men by hand and the other by power mounted on a flat car, the rails being pulled through the bender from another flat car to a car on which they are stored or from which they are distributed upon the ground for laying. The power for doing the pulling may be obtained either from the locomotive or a hoisting engine mounted on

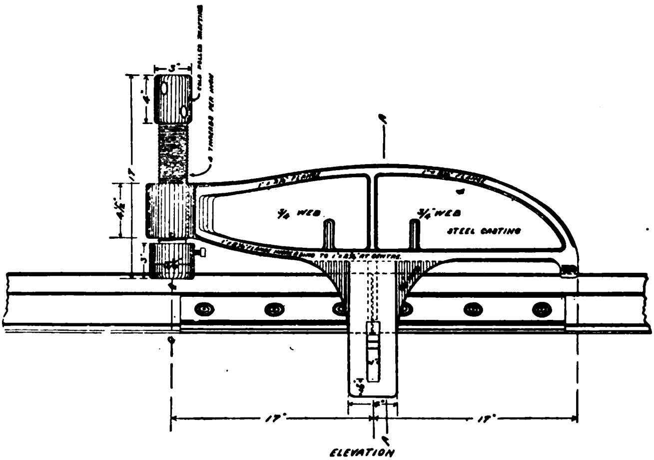


Fig. 45. Vaughan Rail Bender

another car. The common type of curver consists of a semicircular steel yoke, a strap connecting the jaws of the yoke and a plunger between the yoke and the strap, whose position can be regulated by a threaded end which passes through the yoke and a nut abutting against it. The curving is accomplished by the pressure upon the side of the rail of three wheels, two of which are located at the intersections of the strap and the yoke, and the third is carried by the plunger. The

rails are pulled between these wheels, the amount of curve being regulated by the position of the plunger.

With one of these machines, described in the December 18, 1914 number of the Railway Age Gazette, it was found that 20 rails per hour or 200 per day could

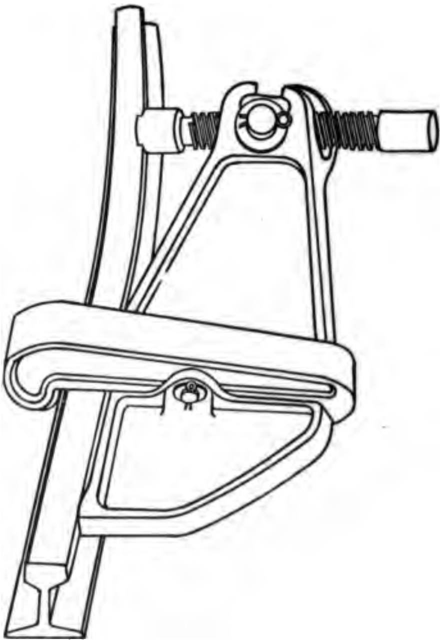


Fig. 46. Superior Reversible Rail Bender

be curved at an expense of about $40 per day or $0.20 for a 33-ft. rail. The force required for operation was eight men and a foreman, assisted by a locomotive. For curving rails in very large quantities a more economical method would be to utilize a platform with a

Middle ordinates in inches for curving rails.

Degree of Curve	Radius in Feet	Length of Rails in Feet 33	30	28	26	24	22	20
0° 30′	11459.	5/32	1/8	3/32	5/64	1/16	3/64	3/64
1° 00′	5730.	9/32	1/4	3/16	5/32	1/8	1/8	3/32
1° 30′	3820.	27/64	3/8	5/16	1/4	7/32	3/16	5/32
2° 00′	2865.	37/64	15/32	13/32	11/32	19/64	1/4	13/64
2° 30′	2292.	45/64	19/32	33/64	7/16	3/8	21/64	17/64
3° 00′	1910.	55/64	45/64	39/64	17/32	7/16	3/8	5/16
3° 30′	1637.	1	27/32	47/64	5/8	33/64	7/16	3/8
4° 00′	1433.	1 9/64	61/64	53/64	23/32	19/32	1/2	27/64
4° 30′	1274.	1 9/32	1 1/16	59/64	51/64	43/64	9/16	15/32
5° 00′	1146.	1 27/64	1 3/16	1 1/32	57/64	3/4	41/64	17/32
5° 30′	1042.	1 9/16	1 19/64	1 1/8	63/64	27/32	45/64	37/64
6° 00′	955.4	1 23/32	1 13/32	1 7/32	1 1/16	29/32	49/64	5/8
6° 30′	881.9	1 7/8	1 17/32	1 11/32	1 5/32	63/64	53/64	11/16
7° 00′	819.0	2	1 41/64	1 7/16	1 1/4	1 1/16	57/64	47/64
7° 30′	764.5	2 9/64	1 3/4	1 17/32	1 21/64	1 1/8	61/64	25/32
8° 00′	716.8	2 9/32	1 57/64	1 41/64	1 27/64	1 13/64	1 1/64	27/32
8° 30′	674.7	2 27/64	2	1 47/64	1 33/64	1 17/64	1 5/64	57/64
9° 00′	637.3	2 9/16	2 3/32	1 27/32	1 19/32	1 11/32	1 9/64	15/16
9° 30′	603.8	2 45/64	2 1/4	1 61/64	1 11/16	1 27/64	1 7/32	1
10° 00′	573.7	2 27/32	2 23/64	2 3/64	1 25/32	1 1/2	1 17/64	1 3/64
11°	521.7	3 9/64	2 19/32	2 1/4	1 61/64	1 43/64	1 13/32	1 5/32
12°	478.3	3 27/64	2 53/64	2 15/32	2 9/64	1 13/16	1 17/32	1 17/64
13°	441.7	3 45/64	3 3/64	2 21/32	2 19/64	1 61/64	1 21/32	1 23/64
14°	410.3	3 63/64	3 19/64	2 7/8	2 31/64	2 3/32	1 25/32	1 15/32
15°	383.1	4 17/64	3 35/64	3 5/64	2 43/64	2 1/4	1 29/32	1 37/64
16°	359.3	4 35/64	3 3/4	3 9/32	2 53/64	2 13/32	2 3/64	1 43/64
17°	338.3	4 27/32	4	3 31/64	3 1/32	2 9/16	2 5/32	1 25/32
18°	319.6	5 1/8	4 7/32	3 43/64	3 3/16	2 45/64	3 9/32	1 7/8
19°	302.9	5 13/32	4 29/64	3 57/64	3 23/64	2 55/64	2 13/32	1 63/64
20°	287.9	5 43/64	4 45/64	4 3/32	3 35/64	3	2 35/64	2 3/32
21°	274.4	5 31/32	4 59/64	4 9/32	3 45/64	3 9/64	2 21/32	2 3/16
22°	262.0	6 1/4	5 5/32	4 1/2	3 29/32	3 19/64	2 51/64	2 19/64
23°	250.8	6 33/64	5 13/32	4 11/16	4 1/16	3 7/16	2 59/64	2 25/64
24°	240.5	6 13/16	5 5/8	4 57/64	4 1/4	3 19/32	3 1/32	2 1/2
25°	231.0	7 5/64	5 53/64	5 3/32	4 13/32	3 47/64	3 5/32	2 19/32
26°	222.3	7 3/8	6 5/64	5 19/64	4 37/64	3 7/8	3 9/32	2 45/64
27°	214.2	7 5/8	6 9/32	5 31/64	4 3/4	4 1/64	3 13/32	2 51/64
28°	206.7	7 59/64	6 35/64	5 45/64	4 15/16	4 11/64	3 17/32	2 29/32
29°	199.7	8 13/64	6 49/64	5 57/64	5 3/32	4 21/64	3 41/64	3
30°	193.2	8 15/32	7	6 3/32	5 1/4	4 31/64	3 13/16	3 7/64

hoist for unloading and loading the rails and a hoisting engine between drums and cables for pulling them through the curver.

Directions for use of the Vaughan rail bender. Seat the device squarely on top of the rail, over the splice, with the slots in the legs at center of splice. Insert the lifting bar in leg slots. Turn up screw until rail and splice are straight.

For straightening bent splices not in track, bolt the splice to two ends, forming a complete joint, and proceed as above.

For use as an ordinary rail bender, lay the device on its side with the legs over and under the rail. Insert bearing blocks, and turn up screw.

A few drops of oil on the screw will very materially lessen the labor of operation.

Printed information for foremen. On all curves it is good practice to have plainly printed signs showing the degree of the curve on one side and the proper elevation therefor on the other side. If for any reason it is not possible for the engineers to give center line stakes for relining curves and to set these markers giving the exact location of point of curve and any change in its degree, the next best plan is to furnish the foreman with a record of the curves on his section and the elevation for each. This may be in pamphlet form convenient to carry with him at all times, such as shown in Fig. 47, page 237. The column "gage" should show the exact gage to maintain; that is, if there is any departure from the standard, on account of widening for the curve.

List of Curves on Section ____________ List of Curves on Section ____________

Beginning at ____________ Beginning at ____________

Ending at ____________ Ending at ____________

Curve No.	Near	Degree	Elevation (inches)	Gage	Curve No.	Near	Degree	Elevation (inches)	Gage

Folding Line

Approved: ____________ Approved: ____________

____________ (Title) ____________ (Title)

Fig. 47. List of Curves on a Section.

XVI

LINING CURVES

One method of lining. Select any part of a curve track which seems to be in the best line for a distance of at least 60 feet, but do not begin at the point of a curve unless you know positively that the curve turns off from the straight track without leaving a swing in the line.

Set two stakes accurately in the center of the track, 60 feet apart, and one in the center of the track at the middle of the 60 feet. These three points are shown in Fig. 48 by the letters A, B and C. Now stretch a cord tight from A to C, and measure from the center of the cord indicated by M to the center stake, B. The result should be your guide as a middle ordinate for the balance of the curve in either direction from where you commence work. We will suppose this middle ordinate to be four inches. You next move the cord 30 feet ahead in the direction in which you wish to line, stopping at B with the end you had first at A, and holding the end of the cord which was at C in your hand until its center is directly opposite and distant just four inches from the track center, at C. You may then set track center D at the end of the cord which you hold in your hand. This process may be carried on until you have set track centers for the whole curve.

After you have set the track centers for the whole curve, procure a gage which is square and true, and mark on the gage, with some sharp instrument, the

correct center between track rails or middle of the gage. Place this gage on the track between the rails and over the track center where you wish to begin lining the rails to place. Then have your men move the track with their lining bars until the center, as marked on the gage, comes directly over the track center point on the stakes. Move the track in this manner

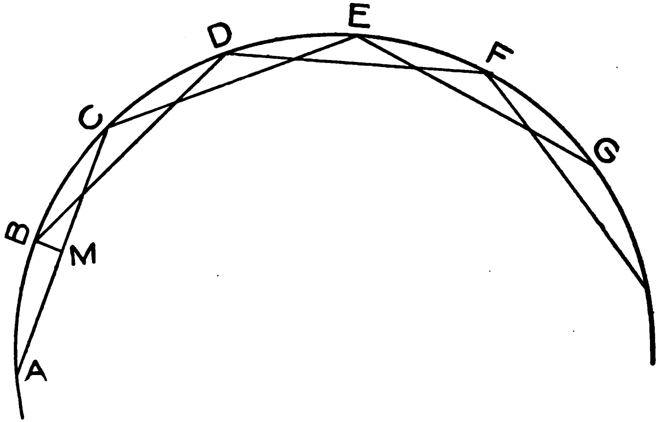


Fig. 48. The Letters A, B, C, to G are Track Centers of a Curve 30 Feet Apart; A C is a 60-Foot Line with which to Ascertain the Middle Ordinate; B M Shows Where the Measurements Should Be Taken to Find the Middle Ordinate.

at every point where you have set a center stake, and then go back over it again, taking out any kinks or other defects left in the line, and you will have a splendid and a true curved line on your track.

Care should be taken not to make any mistakes in measuring the middle ordinates, or in setting the track centers. It will pay to take your time and do the job *well, because* if properly done (like well surfaced

track) it will need to be retouched only in spots afterwards.

By commencing at a rail joint, this method of lining a curve may also be applied to the gage side of the rails, and any defects in the track line can be taken out by moving the rails to place as you go, but the work will not be as accurate nor as reliable as by the process first given. If the rails are 33′ long, use a 66 foot cord or string.

Effect of locomotive and car wheels on curve track. Car wheels which are badly worn on the tread, or close to the flanges, or have the flanges worn sharp, are not safe when passing over switches if there is the slightest "lip" on the rails. They are dangerous also on battered rails, or going around sharp curves, where they are likely to climb the rails and leave the track. Wheels of the kind mentioned have a tendency to hug the rail on their side of the track, and as a consequence make a considerable wear along the gage side of the head of the rail. They also wear spots along the top surface of the outer rail on curves, because, the circumference of the wheel being the same or worn smaller at the flange than at the outside, the wheel must slip by a certain amount in proportion to the degree of curvature, in order to travel as fast as the wheel on the inside rail. When the driving wheels of an engine are allowed to run too long without being turned off, the groove worn in the tire often causes considerable damage to track before the cause is known. Badly worn driving wheels are likely to break the points and wing rails of frogs and cause excessive wear on the stock rails when passing over switches.

Run off. If the curve in the track is a portion of the arc of a circle, it has the same radius right from the point of beginning on the tangent, and consequently should have full elevation at the point of curve as at any other part of it. To insure easy riding

the elevation must commence on the tangent and increase regularly until the curve is reached. It is good practice to run the elevation out fifty (50) feet on the tangent for each inch of elevation. Thus a curve requiring four inch elevation would have the four inches at the point of curve, running out to nothing at a point two hundred (200) feet back on the tangent.

Easements. The practice of running the elevation out on the tangent as above mentioned is not all that may be desired but is the best that can be done when the curve is of the same degree throughout, or, in other words, is a circular curve. To insure easy riding, especially for fast trains, a "spiral" or "easement curve" should be applied to join the tangent with the circular curve. There are several kinds of easements, the principle being that the curve will have a radius varying from infinity at the point of spiral down to the radius of the circular curve at the point where the main curve begins. This permits running the elevation in the same proportion, the elevation increasing just as the degree of curve increases until full elevation is attained where the main or circular curve is reached. The application of spirals or easements in relining curves which were staked out as arcs of circles in the first place is quite complicated and should not be undertaken by trackmen. If it be desired to put spirals on curves, the engineers will have to be called upon to do it, and a record can then be kept of just what change is made.

XVII

SPECIAL CONDITIONS ON MOUNTAIN ROADS

Track work. The winter should find trackmen in the mountains well prepared for the most exacting part of the year's work. The ditches should be cleaned out and all loose rock should be barred down from overhanging walls; otherwise, later, they may be dislodged by the expansive force of ice or by the weight of snow, and roll upon the track. If the cut ends abruptly at a deep fill, the ditch should be extended away from the track along the side of the hill in order to prevent the water cutting unsightly holes in the grade at the end of the cut. At many places the cut is on one side only, the other side being a fill, and where the formation above the track is loose rock, gravel and dirt, this material is very apt to slide down when wet. In such cases the dirt must be cleared from the track and cast down the side of the fill. After a time this fill becomes so wide at this point that the material can no longer be cast over the bank, but must be carried part of the way. This is a very costly manner of doing the work, for it becomes necessary to use wheelbarrows or ditching machines and employ work service, so that the material can be loaded up and wasted on some narrow fill. When large rocks are to be barred out or rolled down, they may be made to roll across the track and down the fill on the other side by laying an inclined platform of ties over the ditch next to the hill. But if for any reason the success of this plan is doubtful or if the walls of the cut rise on

both sides of the track, such large rocks should be blasted before being moved, so that the track may not be obstructed with rocks too large to handle. In all cases the rails below the rock should be protected by ties; if the rock is to be rolled, the ties should be laid along each rail on the side next to the cut, but if blasting is to be done a row of ties should be laid along each side of each rail for forty or fifty feet near the point where the largest rocks are expected to fall; if sufficient ties are not at hand to do this a single row laid on top of the rails may do, but in this case there is no danger of a tie being displaced by one stone and leaving the rail exposed to damage by a heavier one coming after. If ties are not to be had, poles may be cut and substituted. All such rock work should of course be done under the protection of flags.

Cross drains should be cleared out, and if the lower ends empty on loose sand or soil they should be filled around with rock to prevent washing or undermining the drains. All loose, coarse rocks projecting above the ties in the track should be removed before winter sets in, otherwise they may become displaced and roll on the packed snow or ice between the rails and be caught by pilot, snow plow or flanger.

Protection against snow. Every road crossing a mountain range maintains an expensive system of snow fences and snow sheds. At the higher altitudes, on account of the excessive amount of snowfall, fences are ineffective and sheds are built over cuts and other places where the snow is likely to cause trouble, while the fills are generally left exposed because the winds may be depended upon to keep them clear. Where the elevation is low great snow fences are in a measure depended upon to keep the snow from drifting upon the track. The point of elevation at which fences are no longer effective and sheds are necessary varies

greatly in different parts of the country, and must be determined by experience in each particular case. Sheds and board fences are usually built by the carpenter forces, but trackmen are generally expected to look after them and do light repairs, remove grass and other combustible material from sheds, and see that water barrels are kept filled. Before winter sets in salt should be furnished and about two common water pailfuls of it should be put in each barrel, which amount is sufficient to prevent the water from freezing hard enough to injure the barrels. Before putting in fresh salt the barrel should be thoroughly cleaned out.

Clear rails of ice. Particular attention should be given to keeping the rails in snow sheds and tunnels free from ice in winter.

Making snow fences. (See also the chapter on Winter Work.) Sometimes trackmen are required to make snow fences out of poles where timber is convenient. If the ground is not rocky a good fence may be made by beginning at one end and setting an upright forked post; then lay one end of a pole on the ground the other projecting through the fork of the post. The poles should be about twenty feet long, and the upper end should be about eight feet above the ground. After setting the first pole in position, drive cross stakes about four feet from the upright post so that they will lap over the inclined pole; then lay another pole in the crotch thus formed by the stakes and repeat the process until the fence is finished. The cross stakes may be made from the tops of the branches of the poles cut. This makes a good snow fence, but requires a good deal of work.

The portable snow fence similar to that shown in Fig. 49 is about the best form of snow fence in use today where the snow conditions are not too severe.

The rotary plow and flanger. The modern rotary snow plow and flanger have made obsolete the old

snow plow and "snow bucking" outfit, which were always costly and hardly ever effective in keeping the mountain passes open for anything like regular serv-

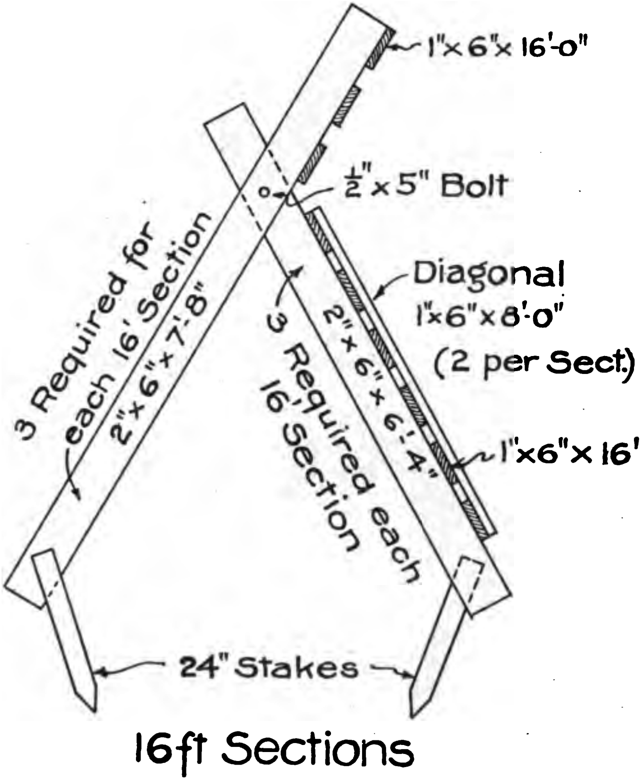


Fig. 49. Portable Snow Fence

ice. If the rotary plow and flanger are kept moving over the line during a storm the section men will have little snow shoveling to do except at switches, station

platforms and snow slides. Turntables on the passes are usually housed in and require no attention.

Water supply. There is sometimes trouble about keeping up the flow of water to the tanks. Those located in the mountains are generally supplied by gravity; that is, there is an underground pipe line up some stream to a point where the intake or upper end of the pipe is higher than the tank. The line is usually laid so deep that there is little danger of freezing, but as an additional precaution the lower end is provided with a waste pipe arranged so that when the tank is full a valve in the lower end of the pipe line is opened and the water flows out through a waste pipe until the water in the tank is lowered by engines to a certain point, when the valve is again closed. By this arrangement water is always flowing through the pipe line, and the likelihood of its freezing up reduced; but the box or housing at the upper end is often broken or filled with sand during a freshet and should be promptly dug out and repaired. It is a very difficult matter to so protect the upper end of the pipe as to admit water freely and still keep out sand and silt.

Expansion. The contraction of rails on mountain roads in the winter does not seem to be greater than on other lines. This is probably accounted for by the fact that while the temperature falls very low in the winter it does not rise high in the summer, so that the range is not excessive. This fact should not be lost sight of in track laying, or relaying steel. The greater the altitude the less expansion needed if the rails are laid in the summer. The rails do not absorb the heat of the sun and become so much hotter than the temperature of the air as they do at lower altitudes. At some passes the thermometer never rises above 80 degrees, and in such places steel laid when the temperature reaches this point would need no al-

lowance for expansion, because whatever movement takes place must be in the way of contraction. Yet steel is sometimes laid in the mountains with the same allowance for expansion required by rules intended and accepted as correct for use in other climates. Where this is done the contraction during the nights, which are always cold in the mountains, and in winter, is so great that the joints are pounded down and rail ends battered by the wheels, and frequently the bolts are broken and the rails pulled apart.

When curves are numerous the "butting back" process should begin at the short rails, if any, at each end of the curve on the inner line of rails, and the closing up process should be done with a view to taking out these rails and using longer ones. When reverse curves are close together, by changing rails on the inside of one curve the expansion may sometimes be adjusted on the outer rail of the next curve.

Washouts. In the spring mountain roads are subject to considerable damage from washouts. These occur not only along water courses, but also in the valleys where the ground is comparatively level and where the track may be at some distance from the stream. A peculiarity of mountain streams is that they rarely cover any considerable territory. There are points where clouds seem to gather or form, and sometimes the fall of water at these places may amount to two or three inches in a few minutes. The downpour of these so-called "cloudbursts" is something tremendous, and of course in such a case the nearest stream is changed in a short time into a torrent, along whose bed are rolled enormous boulders, which strike and break off bridge piles as if they were pipe stems. At other times a cloud may leave some peak or range and, swelling up big and black, move out over a valley and suddenly dump almost its entire contents in a forty-acre field. If there happens to be a railroad

track whose grade is not much above the surface of the ground at this place, it will be flooded or the ballast washed out. Foremen in the valleys soon learn to watch certain points in the mountains for storms that may cause damage to the track, and when it is evident that a serious storm is in progress at such a place flagmen should be sent out to watch the effect on the track and bridges spanning the streams involved. These watchmen should not be withdrawn until all danger is known to be past.

Land slides. The melting snow in the spring at high altitudes softens the ground to such a depth that sandy cuts are always caving in, or loose rocks rolling down. Most of the cuts have one high wall next to the hill and little or no cutting on the lower slope. If the slide cannot be removed by the section gang without delaying trains the division headquarters should be notified, stating the number of feet of track covered, how deep, and whether with gravel, clay or rock. This information should be sent by telegraph or telephone and should always state what forces of men are available nearby or are working on the removal of the obstruction, and the length of time necessary for such a force to clear the track and repair it. Information should be sent in as accurately as possible so that the division officers can estimate what extra help must be provided.

Blasting rocks. At points where large rocks are likely to roll upon the track, a supply of drills, dynamite, and fuse and caps should be kept. If a rock too large to be rolled is found on the track it may be broken by fastening two sticks of dynamite together, attaching the cap and fuse, and laying the charge on top of the rock on a flat surface, if possible. Then, if a smaller rock is laid on top of the giant powder, much additional force of the explosion will be exerted downward. Sticks of dynamite should not be hung over the

side or laid beneath a rock lying on the track, as the explosion is certain to injure the ties or rails. If the rock is too large to be broken as above it must be drilled. A hole equal in depth to one-fourth the thickness of the rock will be sufficient and half a stick of dynamite, properly tamped, will rend a rock weighing several tons. It is best to use a liberal quantity of powder, so that the pieces may be small enough to be handled readily. If the shot misses—that is, if the fuse fails to carry the fire to the cap or the cap does not explode—the hole should not be picked out, as the drill is likely to strike fire and ignite the fuse, or it may hit the cap and cause it to explode. Only experienced men should be allowed to handle dynamite, and it should never be carried in the well or bed of a hand car, as a collision may take place or something be dropped on it and cause an explosion. If it is necessary to carry a few sticks along on a car they should be taken in the pocket or hand of some one who will take care of them. Frozen dynamite will not always explode, and must be thawed out in manure or warm water, not too hot, and never while vessel is in contact with the fire.

Protecting embankments. Much trouble is often experienced in protecting railroad embankments from being cut away by the currents of mountain streams. If the track is in a narrow canyon where the water runs swiftly and deep, solid masonry walls afford the most reliable protection; but if the width of the stream will permit, a good wall having a slope of "one to one" may be made of uncut sandstone by using selected stones from two to three feet square and from six to twelve inches thick. The foundation should, if possible, be laid on bedrock, but in the absence of this the foundation may be of loose rock, laid in a trench about six feet wide and at least three feet below the line of scour in the bed of the stream. Much depends

on getting down below the line of shifting sands during high water, and allowance must be made for the increased depth of scour that may be caused by the water being deflected or confined by the wall. After the loose rock is put in place and interstices filled with sand a line of the large square stones may be laid on top with the face in the center of the foundation and backed by loose rock carefully packed and to a height equal to the top of the first line of stones. Then another layer of stones may be laid on the first, but at a distance back of the first line equal to the average thickness of the stones, when the backing may be again brought up to the level of the stones, and so on, making a wall somewhat like a stairway the height and width of the steps being equal. This makes a good, strong wall at a cost less than solid masonry, but, like the masonry, its life depends largely on the security of the foundation. When sandstone is not to be had, such walls are often built, but without the steps, of smelter slag. This is melted rock, and is heavier than sandstone, and when well laid with the smooth side out presents a nice appearance; but it is impossible to make the pieces fit closely, and, being small, they are easily knocked out of place by floating driftwood, logs, etc., and if the current is swift, in a few years the carefully laid wall looks like common loose riprap. Where the width of the stream is ample, or where there is no reason for building masonry or other walls, ordinary riprap may be employed to protect the embankments. This is made by dumping stones, slag or like material over the bank of the river until it is entirely coated from top to bottom to a depth of from perhaps two feet at the top to ten feet or more at the bottom, depending on the shape of the bank and on the slope given to the riprap. No foundation need be provided, as the loose rock will roll

down and fill up any holes scoured out by the water. The amount of rock on the side of the bank should be in proportion to the depth and volume of water that may pass this point when the river is full. If the course of the stream lies parallel with the track the slope of the riprap may be about one and one-half to one; but if the water strikes the bank at an angle the lower half of the slope should be at least two to one. It may frequently be noticed that a bar of loose boulders a few feet high and sloping into the water at a slight incline will hold its place and turn the course of the stream while if a wall of these same loose boulders were run out into the stream it would be swept away by the first flood. This shows that the current of a stream cannot be turned by loose rock unless it is laid with a long slope or incline, and the longer the incline, especially of the lower portion, the greater will be its power of resistance.

Stone cribs laid parallel to the track or projecting down and outward into the stream are used in many places to prevent the water from cutting away the bank. They are simple in construction, being long boxes made of logs properly notched at the ends, laid somewhat like the walls of a log cabin, or they may be made of timbers. In either case they are drift-bolted at the corners and through the cross stays, which may be placed in rows about ten feet apart, and then the whole is filled with loose rock or slag. When laid on a good foundation they answer the purpose for which they were built very well, but the cost of material and labor required in building the crib is considerable.

Work in tunnels. Repairing track in long, dark tunnels presents problems to the section foreman not often encountered elsewhere. They are cut through formations ranging from loose sand or clay to solid

granite; they may be straight or curved, level, or with a grade uniform from one end to the other, or from the center each way.

If lined with brick or stone they are usually dry; if wood is used there may be wet spots in the tunnel where the water leaks through. If the tunnel is through rock, seams or cracks are often met, through which water pours the year around. In the winter it requires considerable labor in such a tunnel to keep the rails free from ice and attend to the heaved places in the track. In all wet tunnels the ballast should be broken stone, and ample provision made for drainage. If a rock tunnel has but few seams, the water may be kept out by filling them with good cement, but if the rock is badly cracked this cannot be done without considerable expense, although it will probably pay in the end. Open ditches are in most cases relied on to carry off the water, and as they do not fill up except with ice in the winter they are about as good as any system of pipes or tiling. In dry tunnels gravel or cinders, or in fact any material, makes good ballast, because it is not affected by wet weather. Track in tunnels cannot be raised without diminishing the clearance overhead. This clearance is a matter of record and is the basis of information as to what sizes of cars, etc., may be safely sent over the line. Therefore, foremen should not raise track in tunnels without permission from their superiors. The width of tunnels for standard gage track is never less than thirteen feet, and when putting in ties in rock tunnels, it is cheapest to take out two adjoining ones at the same time, even if one is sound and must be put back when the new tie is put in. Fig. 50 will show how ties may be taken out or put in where the width of the tunnel is thirteen feet or more and the ties do not exceed eighteen to the rail.

One tie (a) is taken out on one side and slewed in one direction, and the other (b) on the opposite side and

slewed the other way. Where rock does not interfere ties may be taken out by digging a trench (c), sloping from the rail down and outward to the wall of the tunnel, then pull the tie to that side until the other end can be raised over the other rail and the tie pulled out. As the back end of the trench need be only about

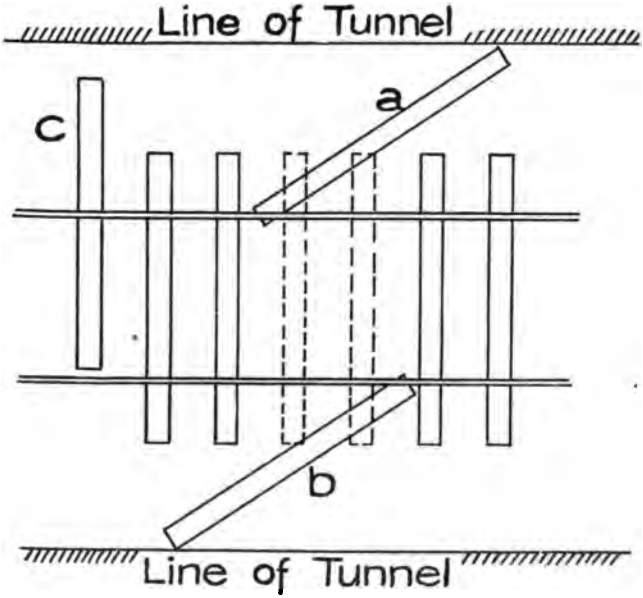


Fig. 50. Replacing Ties in Tunnel

a foot deep, less ballast is handled than in the first method, which should be employed only where a trench cannot be dug. To line track in a long tunnel, get a pole long enough to reach from wall to wall at a point level with the top of the rail, then find and mark the exact center. Next make a mark at the center of the

rail gage, lay the gage and the pole across the track side by side and throw the track until the mark on the gage comes even with the mark on the pole. This may be done to get centers at points fifty feet apart, and then the track can be lined according to those points. If the tunnel is dark a torch or lantern may be held over the rail to give light. The foregoing in regard to tunnels will apply also to track repairs in snow sheds.

XVIII

FROGS AND SWITCHES

Turnouts. A turnout is a curved track by which a car may pass from one track to another, the principal parts of which are a frog and a switch with a connecting piece of track called the "lead." The frog is a device whereby two rails may cross each other in such a manner that a wheel rolling along either rail will have an unobstructed flangeway while crossing the other. A switch consists of two rails, each of which has one end free to move, so connected by cross rods that they move parallel with each other, whereby a car may be switched or shunted from the main track on to the turnout track. Originally switches were generally of the "stub" variety but of late years these have become obsolete and we have now practically only "split" switches or "point" switches, the simplest form of which is shown in Fig. 51.

The upper illustration, Fig. 51, shows the switch set for side track while the lower figure shows it set for the main track. The rails A B & G D are called "stock" rails, are continuous and spiked their full length. E and F are called the "point" rails and are usually fastened at their heels, HH, by angle bars to the lead rails. The point rails are as a rule straight and are planed in such a manner that they bear against the solid rail for a length of 6 or 7 ft. or more. The "throw" of the point, which means the lateral distance that the two switch rail points move at right angles with the main track, in order to change the

route of traffic from one track to another, is about $4\frac{1}{2}$ or 5 in., and the clear space at the heel between gage lines is usually 6 in. or at least 5 in. In order to determine whether a point is a left or right hand one,

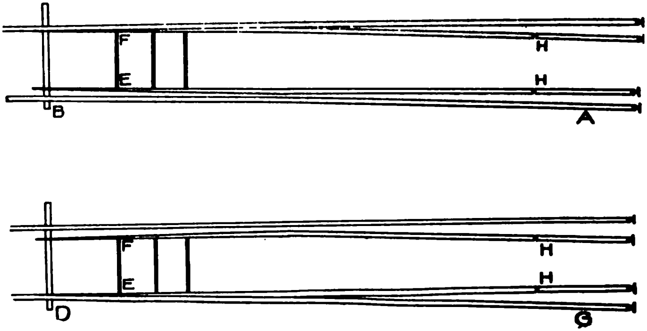


Fig. 51

stand at the point of the switch and face the heel or at the switch and face the frog. The point at your right hand is the right hand switch point and the other one is the left.

Temporary turnouts without frogs and switches. Mr. Andrew Palm, Roadmaster for the C. C. T. Co., was once required to spur out one car, using the ordinary method of stripping out and lining over the track. Upon investigation the ties in the main track were found to be so decayed that they would not survive the operations of digging out, lining over and lining back again. Naturally it was not desirable to renew ties for 60 ft. or more of track in order to spur out one car, and if left undisturbed it was estimated that the old ties had a year or more of life still left in them. Therefore, Mr. Palm used the very ingenious plan which is described below. The spikes were drawn and the main track rails lined over and

connected to the temporary track with angle bars, and spiked to gage, enough short ties being laced in to hold the track meanwhile. The quotations are from Mr. Palm's article in Ry. Eng. & M. of W.

"This is nothing more than the old stub switch method with the frog and guard rails omitted.

"We all know that it is undesirable to place in main lines any switches that are not absolutely necessary, so quite frequently I lay one of these temporary turnouts in preference to the standard switch and frog turnouts. From a safety standpoint, they are ideal, and can be constructed for less than half the cost of the standard point switch.

"Our main lines are laid 'broken joints' and when we decide to lay a track of this character we take two half rails, using one to even the joints at the point where we wish to begin our turnout and the other where the frog would be placed in a standard lead; this half rail is used in place of the frog when we desire to place on or take cars from the temporary siding, by simply releasing the half rail from the main line and laying it in the open space in the turnout, and when the cars have been taken out or placed in, the rail is taken up and relaid in the main line at the beginning of the turnout; all that is necessary is to remove the angle bars from the main line and a few spikes from the inside of one rail, and the same amount of spikes from the outside of the rail opposite back of the joints where this connection is to be made with the turnout; by using the angle bars to make this connection there is no likelihood of a derailment, while there would be if the joints were left open as they were in the days when stub-switches were in vogue.

"I prefer this method for 'spurring out' extra gang outfits to the old way; digging out between the ties for three rail lengths, then opening the main line and

lining the main track out to connect with the temporary spur. This I consider bad practice, as the roadbed is badly disturbed, ties are skewed, which renders it necessary to re-space the ties and to correct the gage of the main line rails after each time the track has been 'cut.'

"By the method which I am submitting, the roadbed is disturbed but very little, the ties not at all, for cross-ties are inserted between those in the main line to support the lead rails.

"I also prefer using this 'layout' instead of tracks with standard turnouts for temporary use by extra gang outfit cars, for we then have the cars isolated, and switchmen and trainmen cannot use the track for storing or setting out commercial cars.

"We continually have complaints from extra gang foremen as to the rough usage their outfits are receiving at night by cars being 'kicked in' against them.

"In the construction of new railroads we find this 'layout' very useful; often we have to construct sidings for track-laying and surfacing gangs, and more often than otherwise we are short of frogs and switches; we lay these sidings at points where permanent sidings are to be located, and later, upon the arrival of the frogs and switches, the standard turnouts are installed.

"Our switch leads are for a No. 10 frog, whose length is 16½ feet, or half the length of a 33-foot rail, so when we 'square' the joints for the temporary turnouts we have done that much toward the installation of the permanent switches.

"Unless we used this temporary lead, we would often be compelled to have our material trains go fifteen to twenty miles to pass each other; we can pass the trains by switching the empty train onto one of these sidings and thereby allow the loaded train to proceed to the front, resulting in the saving of many hours of valuable time. We have passed these trains

with only two trackmen, an assistant foreman and one laborer making the necessary changes.

"In any case where the lined over track is left at a pretty sharp curve, the locomotive should not be pushed in on the curve. The best arrangement is to have a number of empty flats between the car or cars to be spurred out and the locomotive. In this way the

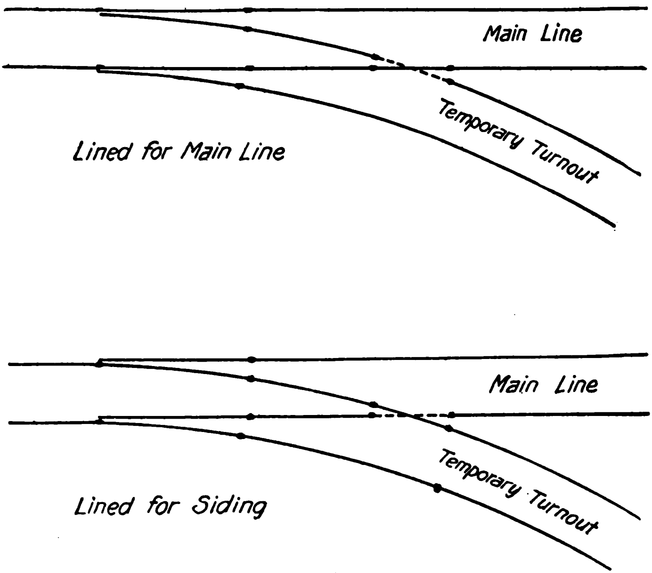


Fig. 52. Turnout Without Frog or Points

light empty flat cars will pass over the track without spreading it or getting off the track as a locomotive is apt to.

"With a well trained and organized gang three or four cars may be spurred out in this way and the track closed in ten minutes, after thorough preliminary preparations have been made."

Laying switches. Locate the frog with a view to cutting the least possible number of rails. After you have determined where the frog point will come, mark the place on the track rail, take from the turnout table the distance from the switch point to point of frog corresponding to the number of the frog which is used. The head block can now be located by measuring the total distance obtained from the frog point.

Make marks with chalk along the flanges of the rail between the head block and frog, so that the switch ties can all be placed the proper distances apart from center to center. After the switch ties have all been arranged according to their proper lengths, lay them

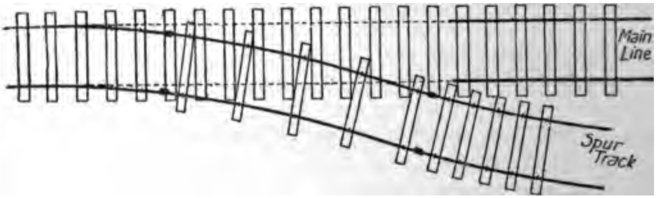


Fig. 53. Method of Spurring Out Cars

out alongside the track, and see that each tie is numbered, and in its proper place as it will lie in the track. Then take out the old ties and pull in each new tie in regular order.

When pulling the ends of the ties to line, time can be saved by using a gauge, made by nailing a cleat across a piece of board, allowing eighteen or twenty inches to project beyond the cleat. Have this gage square at each end, lay it with the cleat against the end of each tie and draw a chalk line across the tie at the end of the board, marking all the ties the same length from the end. This chalk line should be placed so as to mark the position of the outside flange of the rail or where the spikes are to be driven on the line

side. When the ties are all in place under the track, the ends of all the ties will line uniformly on the line side but how closely they will line up on the turnout side depends on how nearly to length the switch ties have been cut or selected to suit the turnout curve. This is a much better way than measuring the end of each tie with a stick or the maul handle. The switch ties should be put in from either end, just as you have the time to spare between trains. If trains are running close together begin at head blocks and select the time longest between trains to put in frog and lead. At least two long switch ties should be put in behind the frog to avoid adzing and crowding short ties past each other where the two tracks separate.

No frog should be put in until the main track guard rail is first secure in its proper place; otherwise the first train that comes along facing the frog may be derailed.

To put in a turn-out proceed as follows:

1. Locate the frog and switch point and put in the turn-out ties, as described in the preceding paragraph.

2. Put slide plates and braces under the unbroken side of main track, placing shims of the proper thickness on the ties at the opposite rail where plates are to be used.

3. Line and full spike the unbroken side on new ties and spike the guard rail to proper position.

4. Couple up frog and main track lead rail and main track switch point on the new ties on the turn-out side, doing such cutting and drilling as may be required to complete the main track lead to the proper length from the point of the switch to the heel of the frog.

5. Break the main track at the position of the heel of the frog and throw the main track rail for the siding, bending the stock rail at the same time. This can be done without taking the stock rail out of the track. Throw in the main track lead, which has al-

ready been coupled, bolt the main track end of the frog, and then spike the new section to the proper gage from the frog to switch, putting on the proper slides and braces.

6. Couple up the switch point for the siding by means of the proper rods, making such adjustments in the rods as are necessary. Cut the rails to complete the siding turn-out from the heel of the switch to the point of the frog, and spike the siding lead to the proper line for the turn-out curve.

7. Complete the work of laying the turn-out by the necessary spiking, gaging and adjustment of switch stand.

Table of switch leads. A great many tables of leads have been published of which, except where one has been copied from another, practically no two are exactly alike. The reason for this is because the lead depends upon a considerable number of factors which vary among the different railroads and with the different lengths of switches and frogs. A large railroad system with modern standards for frogs and switches will nevertheless have a quantity of perfectly serviceable material that is not exactly in accord with the standard drawings and yet which must be utilized in the track. Consequently any one table of leads will not be theoretically correct for all the material on hand.

An elaborate set of tables for a great many different conditions of frog and switch length, etc., is published in the new edition of Practical Switch Work, issued by the publishers of this book.

If a frog is set within a few inches of its theoretical position, provided that the turnout rail be accurately lined, the lead will work properly and no one will notice its lack of theoretical correctness in riding over it, except at very high speed. Therefore it is possible to design a table for average conditions, being

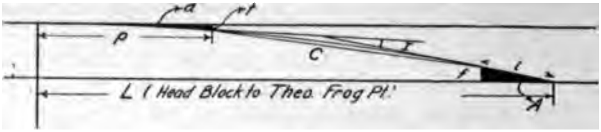
absolutely accurate for those average conditions, and sufficiently near the standards likely to be adopted to work well in practice. Such a table, which was designed to meet just such average conditions, and which has been used in practice for a number of years with entire satisfaction, is given herewith.

With the diagram illustrating the table are given for the use of engineers the formulas by which the table has been calculated.

Arrangement of tables. The table runs from frog numbers 4 to 20 inclusive, with three intermediate frog numbers, 4½, 5½ and 6½. There are other half numbers of course, but they are so little used that it has not been thought worth while to put them in this table.

The first column of the table gives the frog number, the second the frog angle, and the third gives the distance in feet from the theoretical point of frog to the toe of frog. It is here assumed that this distance is in even feet, whereas it frequently happens that it may be 6 ft. 9 in., or 6 ft. 3 in., or 7 ft. 10 in., etc., as the case may be. This, however, will have a very small effect upon the actual length of lead and the distances given in the table are near enough to those actually used in practice for all practical purposes. The fourth column gives the spread of the frog at the toe, based upon the number of the frog and the assumed distance in column 3. It is given in hundredths of a foot, and is the same as that given in the third column, divided by the frog number. The fifth column headed "Planing of Switch Rail," gives the assumed distance from the point of the switch to the point at which the switch rail commences to curve toward the frog, usually where the planing runs out on the head of the switch rail. This also varies a good deal in practice, and theoretically would introduce more variation in the correct theoretical length

Table for point leads.



$\frac{f}{p} = \sin a \qquad \theta = gauge-(t+f) \qquad f = \frac{l}{F}\ (nearly) \qquad L = C\cos y + l\cos A + p$

$\frac{f}{2l} = \sin\frac{A}{2} \qquad C = \frac{\theta}{\sin\frac{1}{2}(A+a)} \qquad R = \frac{C}{2\sin\frac{I}{2}} = \frac{C}{2\sin\frac{1}{2}(A-a)} \qquad I = A-a$

$y = \frac{1}{2}(A+a) \qquad y = \frac{I}{2}+a \qquad \frac{1}{2F} = \sin\frac{A}{2}$

Fig. 54. Switch and Frog Theoretical Layout

Frog Number F	Frog Angle A	Point to Toe of Frog l	Frog Spread at Toe f	Planing of Switch Rail p	Spread of Switch Rail at Heel or end of Planing t	Angle of Switch Rail a	Gauge—(t + f) G	Chord from Planing Point to Toe of Frog C	Radius of Turn out Curve R	Degree of Turn Out Curve. D	Central Angle of Turn out Curve I	"Lead"—Point Switch to Theoretical Frog Point L
4	14° 22′	3′	.75	10′	.42	2° 24′	3.54	24.28	116.5	49° 10′	11° 58′	36.93
4½	12° 46′	"	.67	"	"	"	3.62	27.43	151.6	37° 50′	10° 22′	40.12
5	11° 28′	4′	.80	"	"	"	3.49	28.91	182.9	31° 20′	9° 04′	42.62
5½	10° 26′	"	.73	"	"	"	3.56	31.85	227.4	25° 10′	8° 02′	45.59
6	9° 34′	"	.67	"	"	"	3.62	34.73	277.8	20° 40′	7° 10′	48.48
6½	8° 50′	6′	.92	"	"	"	3.37	34.44	306.8	18° 46′	6° 26′	50.2
7	8° 12′	"	.86	10′	"	2° 24′	3.43	37.13	366.97	15° 40′	5° 48′	52.91
7	8° 12′	"	.86	12′	"	2° 0′	3.43	38.59	356.75	16° 08′	6° 12′	56.37
8	7° 10′	7′	.88	"	"	"	3.41	42.67	473.4	12° 08′	5° 10′	61.49
9	6° 22′	"	.78	"	"	"	3.51	48.12	631.5	9° 05′	4° 22′	66.95
10	5° 44′	8′	.80	"	.22	1° 03′	3.69	62.37	763.3	7° 31′	4° 41′	82.22
11	5° 13′	"	.73	"	"	"	3.76	68.79	946.0	6° 04′	4° 10′	88.66
12	4° 46′	"	.67	"	"	"	3.82	75.29	1161.	4° 56′	3° 43′	95.16
13	4° 24′	"	.62	"	"	"	3.87	81.40	1392.5	4° 07′	3° 21′	101.29
14	4° 06′	"	.57	"	"	"	3.92	87.25	1639.3	3° 30′	3° 03′	107.15
15	3° 49′	"	.52	"	"	"	3.96	93.27	1931.7	2° 58′	2° 46′	113.17
16	3° 35′	"	.50	"	"	"	3.99	98.71	2232.7	2° 34′	2° 32′	118.61
17	3° 22′	"	.47	16′	"	0° 47′	4.02	111.03	2462.8	2° 20′	2° 35′	134.94
18	3° 11′	9′	.50	"	"	"	3.99	115.29	2752.5	2° 05′	2° 24′	140.71
19	3° 01′	"	.47	"	"	"	4.02	121.25	3110.9	1° 50′	2° 14′	146.18
20	2° 52′	"	.45	"	"	"	4.04	126.71	3449.3	1° 40′	2° 05′	151.77

of lead and variations in the distance from point of frog to the toe of frog, but as we have said above, it is sufficiently accurate for all practical purposes of this table. The next column, headed with a small "t," "Spread of Switch Rail at Heel or End of Planing," gives the distance separating the switch rail

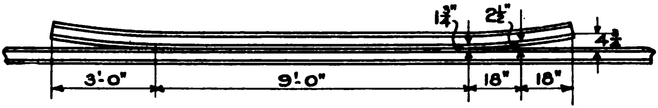


Fig. 55. Typical Guard Rail

from the main rail at the point where the switch rail starts to curve toward the frog, and where this is at the end of planing it will be equal to the width of a rail head, or about 0.22 of a ft. The column headed "G" is the gage of the track minus the spread of toe of the frog and the spread of the switch rail at heel or end of planing. The other columns are explained by their captions in the table.

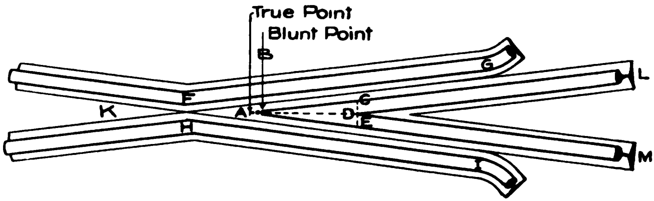


Fig. 56. Standard Frog

Frogs. Fig. 56 is an outline diagram of a frog. The triangle C A E is the tongue. C E is the heel of the tongue. The channel at K is the mouth. Its narrow part, F H, is the throat. The wings, F G, and H I, support the treads of the wheels from the point B, to the throat. L M is the heel of the frog. The

angle is the divergence of the lines, A C and A E. The intersection of the lines at A is the true "theoretical" point of the frog. As this point is too weak for service, it is rounded off where the tongue is about one-half inch wide. The frog number is the ratio of the perpendicular, A D, the length of the point to the base, C E. Thus, if the length, A D, be 7, 9 or 10 times C E, the frog is called a No. 7, 9 or 10 frog. The angle of the frog is determined approximately by dividing $57\frac{3}{10}$ degrees by the number of the frog. To get the number of a frog one of the following ways may be used:

1. Take a short stick say six inches long, lay this on

Fig. 57. Conley All Rail Frog

the heel of the frog where the spread of the frog equals the length of the stick; then from this point measure with the stick to the theoretical point of the frog; if it is seven times the length of the stick it will be a number seven; if eight times, a number eight, etc.

2. Measure with a rule and find where the spread is four inches; mark this point; then get where it is five inches; also mark this; then the length in inches from where it is four to five inches measured along the rail will be the number of the frog.

3. Add the spread between the gage lines at the heel to the spread at toe in inches and divide this into total length of frog in inches; the result will be the number.

4. Divide the spread between gage lines at the heel of frog in inches into length along the rail from heel to theoretical point in inches; result will be the number.

5. Divide the spread between gage lines at toe in inches into length along rail from toe to theoretical point in inches; the result will be the number.

In order to make the main line rail as continuous as possible, spring frogs are introduced. These are right and left handed. To determine whether right or left, stand at the toe and face the heel; if the spring rail is at the left it is left-handed; if at the right, it is right-handed.

Laying frogs in track. When putting frogs into a track care should be taken to have them in a true line and level with the track rails which are connected to them. The gage rail, opposite the frog, should be put to a perfect gage for the full length of the frog. Foremen should see that frogs are not allowed to fill up with ice or snow in the winter season, and when foot guards for the protection of trainmen are provided, it should be seen to that they are always kept properly in place to prevent any liability of accident.

Length of frogs. Long frogs and long switch leads are best where it is practicable to use them; the rails in short switch leads soon wear out. If the switch lead is long, the saving effected in the wear of the rails and rolling stock is considerable. A valuable feature in a frog is to have it of such a length that very little cutting of rails is necessary when putting in a new switch. When full length rails can be used in a switch it saves time, labor and material. For this purpose a foot or two is often added to the lead.

Crossing frogs are used where one track crosses another. They are generally supported by long ties or switch timber. Where one road is double-tracked, the frogs are difficult to keep in line, owing to the

tracks of the double line often creeping in opposite directions.

Guard rails. The guard rail at frogs is used to prevent the car and locomotive wheels from crossing the point of the frog on the wrong side when trains are passing over it. The length and shape of a guard rail adopted as the standard should be used with all frogs in service on the same road. Guard rails should be preferably ten feet in length or over; fifteen feet and fifteen and a half feet are ordinary lengths; for the higher numbered frogs longer ones are used. Enough of the middle of the guard rail should be spiked down parallel with the track rail, opposite the point of the frog, to secure ample protection. The guard rail may be secured by spiking it to the ties and by clamps, or by passing a bolt through the guard rail and track rail at each side of that part which is parallel with the track rail, leaving between the two rails a wheel channel. This makes it unnecessary to use braces except as additional precaution. Fillers or separators may be used on the bolts between the webs of the guard and track rails, to regulate the width of the wheel channel, which should never be more than two inches on a standard gage track. Also clamps may be used; these are of great advantage, especially when a guard rail fills with snow.

The extreme ends of the guard rail should be spiked to the ties at a distance of four inches from the track rail. This will give the wheels an easy and gradual approach to the narrower space where the rails are parallel. Guard rails should not be sprung to place with the track spikes but should be bent to the proper shape before being laid.

When guard rails are made in the company's shops their ends should be heated and hammered down or cut on a bevel of 45° to form a gradual approach or

slanting surface from the base of the rail, where it rests on the ties, to the top. This may prevent brake beams, chains, or snow plows, etc., from catching on the end of the guard rail and tearing it out of place. It is well to take the same precaution with the ends of guard rails that cross bridges or go around curves inside the rails on main track. See Fig. 55.

Guard rails are necessary on a railroad, and if the track foreman has to provide them when he puts in a new switch the piece of rail which is cut from a full length rail to let in the frog will often serve for a guard rail; when long enough it should always be used instead of cutting another good rail. The width of wheel flangeway between the guard rail and track rail should be from 1¾″ to 1⅞″, and no more, if the wheel flangeway through the frog is 1¾″ and the track is to gage.

A frequent error in practice is to place the guard rail so that its center will come even with the point of the frog. The effect of this is to jerk trailing wheels against the end of the frog wing rail, and if the gage of track happens to be wide the frog bolts will be broken. Even if the track is in proper gage the end of the guard rail projecting beyond the end of the wing of the frog will throw worn flanged wheels (because of their greater lateral play) against the frog wing, thus subjecting an already weak flange to the danger of being broken, whereas if the projecting guard rail did not alter the course of the wheel it would enter the frog without a shock. The province of a guard rail is to guide the facing wheel flange safely past the point of the frog, and where the wheel has passed this point, be it but one inch, it has no further use for a guard rail. Therefore about two-thirds of the guard rail should be ahead of the point of frog to get the greatest amount of protection with the ma-

on getting down below the line of shifting sands during high water, and allowance must be made for the increased depth of scour that may be caused by the water being deflected or confined by the wall. After the loose rock is put in place and interstices filled with sand a line of the large square stones may be laid on top with the face in the center of the foundation and backed by loose rock carefully packed and to a height equal to the top of the first line of stones. Then another layer of stones may be laid on the first, but at a distance back of the first line equal to the average thickness of the stones, when the backing may be again brought up to the level of the stones, and so on, making a wall somewhat like a stairway the height and width of the steps being equal. This makes a good, strong wall at a cost less than solid masonry, but, like the masonry, its life depends largely on the security of the foundation. When sandstone is not to be had, such walls are often built, but without the steps, of smelter slag. This is melted rock, and is heavier than sandstone, and when well laid with the smooth side out presents a nice appearance; but it is impossible to make the pieces fit closely, and, being small, they are easily knocked out of place by floating driftwood, logs, etc., and if the current is swift, in a few years the carefully laid wall looks like common loose riprap. Where the width of the stream is ample, or where there is no reason for building masonry or other walls, ordinary riprap may be employed to protect the embankments. This is made by dumping stones, slag or like material over the bank of the river until it is entirely coated from top to bottom to a depth of from perhaps two feet at the top to ten feet or more at the bottom, depending on the shape of the bank and on the slope given to the riprap. No foundation need be provided, as the loose rock will roll

Bills of material of switch ties for various turnouts and crossovers.

SWITCH TIES FOR No. 6 TURNOUT

No.		Size	Length
2	pc.	7″ × 9″	Head blocks
6	“	“	9′—0″
5	“	“	9′—6″
5	“	“	10′—0″
2	“	“	10′—6″
2	“	“	11′—0″
2	“	“	11′—6″
2	“	“	12′—0″
2	“	“	12′—6″
2	“	“	13′—0″
2	“	“	13′—6″
2	“	“	14′—0″
2	“	“	14′—6″
2	“	“	15′—0″
36	“	Total = 2134′ B.M.	

Exclusive of head blocks.

SWITCH TIES FOR No. 7 TURNOUT

No.		Size	Length
2	pc.	7″ × 9″	Head blocks
6	“	“	9′—0″
6	“	“	9′—6″
5	“	“	10′—0″
4	“	“	10′—6″
3	“	“	11′—0″
2	“	“	11′—6″
2	“	“	12′—0″
2	“	“	12′—6″
2	“	“	13′—0″
3	“	“	13′—6″
2	“	“	14′—0″
3	“	“	14′—6″
2	“	“	15′—0″
42	“	Total = 2499′ B.M.	

Exclusive of head blocks.

SWITCH TIES FOR No. 8 TURNOUT

No.		Size	Length
2	pc.	7″ × 9″	Head blocks
9	“	“	9′—0″
7	“	“	9′—6″
4	“	“	10′—0″
3	“	“	10′—6″
3	“	“	11′—0″
3	“	“	11′—6″
2	“	“	12′—0″
2	“	“	12′—6″
3	“	“	13′—0″
3	“	“	13′—6″
3	“	“	14′—0″
2	“	“	14′—6″
2	“	“	15′—0″
46	“	Total = 2708′ B.M.	

Exclusive of head blocks.

SWITCH TIES FOR No. 10 TURNOUT

No.		Size	Length
2	pc.	7″ × 9″	Head blocks
9	“	“	9′—0″
10	“	“	9′—6″
6	“	“	10′—0″
4	“	“	10′—6″
4	“	“	11′—0″
3	“	“	11′—6″
3	“	“	12′—0″
3	“	“	12′—6″
2	“	“	13′—0″
3	“	“	13′—6″
3	“	“	14′—0″
2	“	“	14′—6″
3	“	“	15′—0″
55	“	Total = 3215′ B.M.	

Exclusive of head blocks.

Switch Ties for No. 12 Turnout

No.		Size	Length
2	pc.	7″ × 9″	Head blocks
11	"	"	9′—0″
10	"	"	9′—6″
8	"	"	10′—0″
7	"	"	10′—6″
5	"	"	11′—0″
4	"	"	11′—6″
4	"	"	12′—0″
3	"	"	12′—6″
3	"	"	13′—0″
3	"	"	13′—6″
3	"	"	14′—0″
3	"	"	14′—6″
5	"	"	15′—0″
69	"	Total = 4062′ B.M.	

Exclusive of Head blocks.

Switch Ties for No. 15 Turnout

No.		Size	Length
2	pc.	7″ × 9″	Head blocks
14	"	"	9′—0″
9	"	"	9′—6″
9	"	"	10′—0″
7	"	"	10′—6″
6	"	"	11′—0″
5	"	"	11′—6″
5	"	"	12′—0″
5	"	"	12′—6″
4	"	"	13′—0″
4	"	"	13′—6″
4	"	"	14′—0″
4	"	"	14′—6″
4	"	"	15′—0″
80	"	Total = 4730′ B.M.	

Exclusive of Head blocks.

Switch Ties for No. 20 Turnout

No.		Size	Length
2	pc.	7″ × 9″	Head blocks
18	"	"	9′—0″
18	"	"	9′—6″
8	"	"	10′—0″
8	"	"	10′—6″
7	"	"	11′—0″
7	"	"	11′—6″
6	"	"	12′—0″
9	"	"	12′—6″
9	"	"	13′—0″
6	"	"	13′—6″
6	"	"	14′—0″
5	"	"	14′—6″
5	"	"	15′—0″
5	"	"	15′—6″
5	"	"	16′—0″
122	"	Total = 7486′ B.M	

Exclusive of Head blocks.

Switch Ties for No. 6 Crossover

No.		Size	Length
4	pc.	7″ × 9″	Head blocks
12	"	"	9′—0″
10	"	"	9′—6″
10	"	"	10′—0″
4	"	"	10′—6″
4	"	"	11′—0″
4	"	"	11′—6″
4	"	"	12′—0″
22	"	"	21′—6″
70	"		Total = 5019′ B.M.

Exclusive of Head blocks.

Switch Ties for No. 7 Crossover

No.		Size	Length
4	pc.	7″ × 9″	Head blocks
12	"	"	9′—0″
12	"	"	9′—6″
10	"	"	10′—0″
8	"	"	10′—6″
6	"	"	11′—0″
4	"	"	11′—6″
4	"	"	12′—0″
26	"	"	21′—6″
82	"		Total = 5906′ B.M.

Exclusive of Head blocks.

Switch Ties for No. 8 Crossover

No.		Size	Length
4	pc.	7″ × 9″	Head blocks
18	"	"	9′—0″
14	"	"	9′—6″
8	"	"	10′—0″
6	"	"	10′—6″
6	"	"	11′—0″
6	"	"	11′—6″
4	"	"	12′—0″
32	"	"	21′—6″
94	"		Total = 6872′ B.M.

Exclusive of Head blocks.

Switch Ties for No. 10 Crossover

No.		Size	Length
4	pc.	7″ × 9″	Head blocks
18	"	"	9′—0″
20	"	"	9′—6″
12	"	"	10′—0″
8	"	"	10′—6″
8	"	"	11′—0″
6	"	"	11′—6″
6	"	"	12′—0″
31	"	"	21′—6″
109	"		Total = 7618′ B.M.

Exclusive of Head blocks.

Switch Ties for No. 12 Crossover

No.		Size	Length
4	pc.	7″ × 9″	Head blocks
22	"	"	9′—0″
20	"	"	9′—6″
16	"	"	10′—0″
14	"	"	10′—6″
10	"	"	11′—0″
8	"	"	11′—6″
8	"	"	12′—0″
39	"	"	21′—6″
137	"		Total = 9618′ B.M.

Exclusive of Head blocks.

Switch Ties for No. 15 Crossover

No.		Size	Length
4	pc.	7″ × 9″	Head blocks
28	"	"	9′—0″
18	"	"	9′—6″
18	"	"	10′—0″
14	"	"	10′—6″
12	"	"	11′—0″
10	"	"	11′—6″
10	"	"	12′—0″
52	"	"	21′—6″
162	"		Total = 11734′ B.M.

Exclusive of Head blocks.

SWITCH TIES FOR No. 20 CROSSOVER

No.	Size	Length
4 pc.	7″ × 9″	Head blocks
36 "	"	9′—0″
36 "	"	9′—6″
16 "	"	10′—0″
16 "	"	10′—6″
14 "	"	11′—0″
14 "	"	11′—6″
12 "	"	12′—0″
63 "	"	21′—6″
207 "	Total = 14742′ B.M.	

Exclusive of Head blocks.

To cut switch ties of the proper length.

RULE—Measure the length of the tie next the head block and also the length of the last tie behind the frog. Find the difference in inches between the lengths of the two ties, divide this amount by the number of ties in the switch lead, and the quotient should be the increase in length per tie from the head block towards the frog, to have the ties line evenly on both sides of the track.

EXAMPLE—We will suppose the tie next to the head block to be 8 feet 6 inches, or 102 inches in length, and the last tie behind the frog, 14 feet or 168 inches in length. The difference in the lengths of these two ties is 5 feet 6 inches, or 66 inches; dividing by 33, the number of ties, gives 2 inches as the amount that each tie must be longer than the last.

Section foremen will find this rule valuable in many cases, especially when putting in a cross-over from one track to another. There is nothing gained by having switch ties project beyond the proper line of track. They cause trouble in raising track, are unsightly, and labor is wasted in tamping up the long ends. The switch ties may be cut off to the proper

length and numbered with chalk, and the line side marked for the rail flange before being put in the track. The work can be done in that way more rapidly and better, and the unnecessary labor of digging out for the tamping up of long ends can be dispensed with.

Tamping switch ties. When a switch track has been raised, to surface the track the switch ties under the frog and main track rail should be tamped up first. The long ends of switch ties should be tamped up last and then not as solid as those under the frog. Tamping bars should be used in tamping up a switch, and special care should be taken to make the ties as solid as possible under the frog. A turnout is all the better if the frog is a shade higher than the remainder. If the outer ends of switch ties are tamped up first, unless the timbers are very large they will sag down in the center and the ends turn up, especially if a train is allowed to pass over the switch before the ties are tamped throughout their length.

A set of switch timbers may be put into a mud track very quickly, and with little or no tamping, by the following method:—Remove all the old timbers except a few to support the track rails. Raise the rails on the supporting ties about a quarter of an inch higher than the track surface, and level them with a spirit level. Clear away a bed for the timbers equal to their depth, and spread a little loose dirt on it; then pull in the timbers, keeping their upper surface close up to the rails and each timber level throughout its length until it is in place.

Putting in three-throw switches. The length of switch ties in a three-throw switch is found by doubling the set for a single turnout, and subtracting the length of the standard cross tie. When putting them in the track, measure the length of each tie and draw a chalk line across the middle; mark also the

middle of the gage. Lay the gage on the main track, and as each tie is put under the track, see that the chalk mark across the middle of the tie comes directly under the middle of the gage of the main track. The approximate number of the middle or crotch frog is found by multiplying the number of the side frogs by the decimal .707, or by adding the numbers of the two side frogs together and dividing by 2.83.

Derailing switches. Fig. 58 illustrates a method of derailing cars and is used in cases where precautions are required to prevent cars from accidentally running out of the siding upon the main track. When putting in this derailing switch, drive a row of spikes against the inside flange of the rail, C, when set for

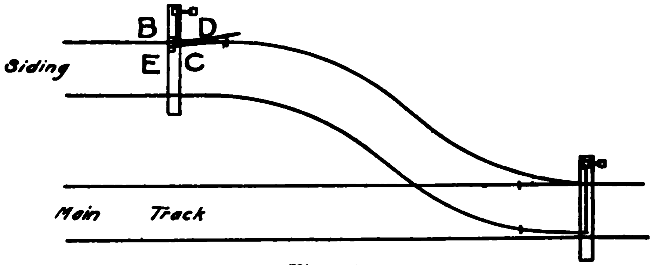


Fig. 58

derailing and place rail braces on the outside to support and keep the rail in place when set for movement to the main track. It is good policy to use sound oak ties, spaced not more than eight inches apart under the moving rail. This presents a smoother surface for the derailed cars than ties spaced in the ordinary way, and prevents the wheels from sinking between them.

In setting up switch-stand, have the target show danger when the switch is set for derailing.

Turnouts from curves. In turnouts from curves, the lead distance is practically the same as in turnouts from a straight track. The degree of curve of the turnout is approximately increased by the degree of the main track curve, when the turnout is with the curve; and decreased by the degree of the main track curve, when the turnout is against the curve. In turnouts against curves, when the degree of the main track curve is the same as the turnout curve corresponding to the frog, the lead will be straight; when greater, the turnout curve will deflect in the same direction as the main track curve. As curves for the ordinary frog numbers are sharp, avoid as much as possible turnouts from the inside of the curve.

In turnouts from curves the ordinates for a straight track will be increased by a certain rate per degree of main track curve, when the turnout is laid with the curve; and decreased by the same rate per degree when the turnout is laid against the curve.

EXAMPLE:—(1) Turnout against a main track curve of 4°, with a No. 8 frog. In the table for point leads, page 264, the degree of the turnout curve (Column D) from a straight track for a No. 8 lead is 12°–08′. Subtract from this the degree of the main curve 4°–00′ and we have the difference of 8°–08′, for the degree of curve of the switch track, which will curve in a direction opposite to that of the main track.

(2) Turnout against a main track curve of 8°, with a No. 10 frog. Here the degree of the main track curve is 8°–0′; degree of the turnout, from table, 7°–31′. This is flatter than the main curve by 0°–29′, and the switch curve therefore will be in the same direction as the main track. Note that these figures are approximate only, and are subject to the remarks in the paragraph introductory to the table of Leads.

Cross-over tracks. To put in a cross-over from one track to another where the work has not been laid out by an engineer:

RULE—Put in the first frog and switch lead complete on one track. Then sight a straight line along the gage rail from opposite the point of frog, which you have just put in track, to the nearest rail of the adjoining track. Where the line crosses the rail is where the point of the next frog ought to be located to complete the cross-over if both frogs are of the same angle.

To find the approximate distance between frog points in a cross-over: For 12-foot centers multiply 2.58 by the number of the frog. If the distance between centers is less than 12 feet, subtract the difference from 2.58; if more, add the difference. Thus: Find distance between frog points on a No. 10 cross-over, distance between track centers, 12 feet; 2.58 × 10, equals 25.8 feet.

If the center distance is 11 feet, we have as follows: Eleven feet is one less than 12 feet; hence we subtract 1 from 2.58 and we have 1.58; if a No. 10 cross-over is to be put in we have: 1.58 × 10, or 15.8. If the center distance were 13 feet we would have 3.58 × 10, or 35.8. These measurements are made on the main line rail.

Another method, which is particularly important when the frogs used in the cross-over are of different angles, is as follows: Add the numbers of the two frogs together and divide by two. The result is the average number of frog for cross-over; now multiply this by the distance between gage lines of inside rails, less the gage; or, where the distance between centers of two tracks is used, subtract twice the gage from this distance and multiply by average number of frog.

EXAMPLE. Distance between centers of two tracks

is 12 ft. It is desired to put in a cross-over, using a No. 10 and No. 8 frog. Proved according to rule: $10 + 8 = 18$ divided by 2 equals 9. Then $2.58 \times 9 = 23.22$ ft.

The distance between frog points diagonally in any cross-over track put in with the frogs mentioned in the table, for distances between tracks of 10 to 15 feet is shown in the following table. Where the distance between two tracks is greater than 12 feet, foremen can calculate the distance between the frog points by the rules preceding this table:

	DISTANCE BETWEEN ADJACENT RAILS IN FEET					
Frog No.	7	8	9	10	11	12
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
5	11–6	16–6	21–6	26–6	31–6	36–6
6	13–9	19–9	25–9	31–9	37–8	43–8
7	16–0	23–0	30–0	37–0	44–0	51–0
8	18–4	26–4	34–4	42–4	50–4	58–4
9	20–8	29–8	38–8	47–8	56–7	65–8
10	23–0	33–0	43–0	53–0	63–0	73–0
11	25–3	36–3	47–3	58–3	69–3	80–2
12	27–6	39–6	51–6	63–6	75–6	87–6
15	34–4	49–4	64–4	79–4	94–4	109–4
16	36–8	52–8	68–8	84–8	100–8	116–8
20	46–0	66–0	86–0	106–0	126–0	145–9

A reverse curve can be made in the cross-over between tracks when they are very far apart, and there is not room to set it in the regular way.

Staggered switch points on any curve. Mr. W. F. Rench of the P. R. R. has given in Ry. Age Gaz., the following very interesting description of a convenient and useful device for use on curves where the switch points are subject to heavy wear:

"Considerable economy is effected in the wear of switch points in yards at points where the service is extreme by moving the point of lesser wear back a distance of 26 in., so that the first lug of the one point and the second lug of the other are opposite, and in-

troducing a guard rail 9 or 10 ft. long curved sharply through 12 in. at the end which covers the switch and in the standard manner at the other end. The guard rail is set close to the one point which permits 12 in. of 2 in. flangeway opposite the longer point. This greatly increases the life of the point and is an excellent protection against derailment as well. One set of lugs must be connected with the standard head rod and for entire safety each lug should be connected with the one diagonally opposite. If made on a standard plan these rods may be of regulation design, but if resort must be had to makeshift designs a flat made rod of 2½ in. by ½ in. material is quite satisfactory. Care should be taken that the guard rail, which is subject to a severe strain, is braced by anchor clamps and at least one tie plate guard rail fastener.

"This arrangement has been used in a number of places where the wear is severe, but perhaps in none where the conditions are as extreme as at two switches in the Midvale Branch, a siding leading to the Pennsylvania's Nicetown (Philadelphia) freight station, and to the plant of the Midvale Steel Company. These two switches follow each other closely and spring from the inside of a 17-deg. curve. Approximately 30 movements are made over these switches every day.

"At each one of the switches the high side point, applied new of P. R. R. 100-lb. material, formerly lasted just two months, it being a matter of actual knowledge that 12 switch points were consumed in the two places within a period of one year. Besides, it was the rule for a derailment to herald the time for renewal which by reason of the difficulties of access to this location usually involved an expense for the wrecking and repair of equipment equal to the value of a new point. It is three years since the points now in track, which were then close to the limit of safe wear, were cut back and the guard rails applied and

it is quite probable the points will still last two years longer. At this one location 60 switch points will have been saved in a period of five years, which represents at least $1,200 in money. (Fig. 59.)

Turnouts for narrow-gage track on industrial railway. Mr. Ralph D. Brown of the O'Gara Coal Company has given the following useful notes which were published in Eng. News in 1916.

The development of narrow-gage railway track is confined chiefly to limited layouts for industrial plants and to mining operations where limited clearances ne-

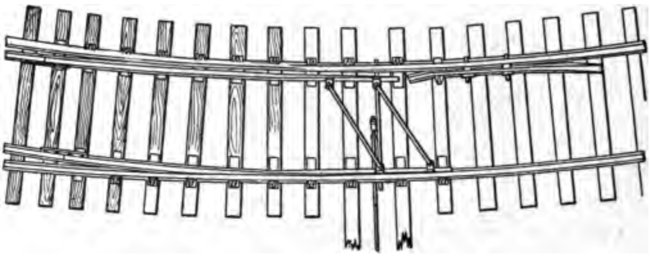


Fig. 59. Staggered Switch Points on a Curve of Heavy Wear

cessitate its use. A coal mining company operating many mines which had been developed independently was forced by economic necessity to standardize its equipment. As some of the mines were already developed extensively, it was not considered advisable to relay the tracks entirely to change the gage, but it was found possible to use one type of frog and switch for all turnouts.

Standard designs were adopted, and the results of computations were placed in tabular form for the use of the construction gang. Certain assumptions had to be made, such as the length of the wing rails of the frog and the heel distance of the switch, but they were all within the limits of accepted practice and

can be applied to any industrial-track system. The designs of the frog and switch point, shown in Fig. 60 were made after considering both simplicity and economy of construction. Any ordinary blacksmith or ironworker will make these parts without difficulty. The cost of making a No. 5 frog and two 6-ft. switch points at a well-equipped mine shop was as follows:

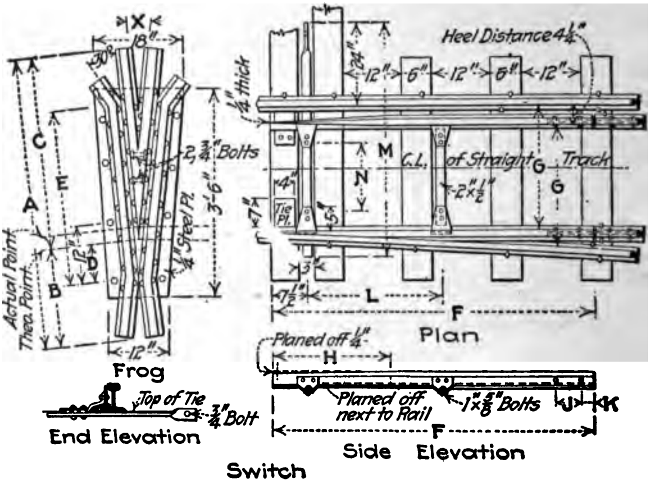


Fig. 60

Material, $6.37; labor of blacksmith and machinist, $6.58; total, $12.95.

A cast-steel frog supplied by manufacturers at a cost of about $6.50 is inherently more rigid than the riveted frog, but unless unusual precaution is taken it is difficult to fasten it securely to the ties. In order to stiffen the riveted structure, cast-iron fillers may be added which also support the flanges of the wheels in passing over the throat of the frog, thus relieving the jar to the rolling stock.

In designing various parts of the turnouts it was kept in mind that all such turnouts may be of only temporary usefulness in one particular location, and that the constituent parts may be used many times before being cast aside as useless. The standard frog is somewhat shorter than one designed to the specifications of the American Railway Engineering Association.

The cost of laying and ballasting a No. 5 turnout complete, as shown in Fig. 61, was as follows:

One 30 lb. No. 5 frog and two 6 ft. points	$12.95
40 ties, 5x6 in., @ 20c	8.00
Spikes, bolts, tie plates, etc.	.75
1 low switch stand and rods	2.25
2 headblocks, 5x6 in.—8 ft. long	1.00
Total material	$24.95
Laying, 16 hr. @ 35½c.	5.68
Ballasting and surfacing, 8 hr. @ 35½c.	2.84
Total labor	$8.52
Total cost of material and labor	$33.47

The dimensions of the standard frogs, switches and turnouts are given at the end of Chapter XXIII. The formulas used for the turnouts are as follows:

$$\text{Chord length } U = \frac{G - B \sin X - F \sin Y}{\sin \frac{1}{2}(X + Y)}$$

$$\text{Radius } R = \frac{G - B \sin X - F \sin Y}{\cos Y - \cos X} - \tfrac{1}{2}G$$

$$\text{Lead } S = (R + \tfrac{1}{2}G)(\sin X - \sin Y) + B \cos X + F + O$$

in which

X = Frog angle;
Y = Angle of point rail;
B = Length of wing rail;
F = Length of switch rail;

O = Distance between actual and theoretical frog point, taken as 2 in.;
G = Gage of track;
R = Radius of turnout.

The dimension of O was taken as 2 in. and the heel distance of switch points as $4\frac{1}{4}$ in.

The spacing of the ties depends on the size of the tie and the style of the turnouts. If the regular set of switch ties is used as in standard-gage trackwork, 5 x 6-in. ties spaced 18 in. c. to c. will give good results for track laid with rails weighing up to 40 lb. per yd. If the turnout is laid with ties of even length

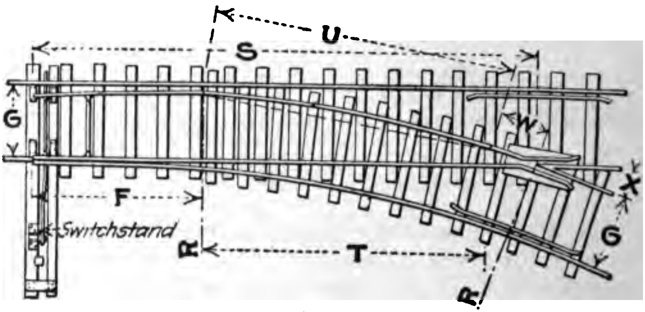


Fig. 61

staggered in, as shown in Fig. 61, a spacing of 16 to 18 in. centers for each branch has proved satisfactory. This style of construction is specially well adapted to underground turnouts, where headroom is limited and flat ties 3 by 5 in. or 3 by 6 in. are used.

Too often the trackwork for mines and industrial works is poorly executed, due to lack of experience of the tracklayers and construction foremen. The essential requirements do not differ from those of the standard gage, and true alignment and surface may be obtained by intelligent supervision.

Crossing of narrow and standard gage track. Mr. T. C. Herbert of the P. C. C. & St. Louis Ry., in connection with the second track and grade reduction work on that road between Alton, Ohio, and Glade Run, as described in the Ry. Age Gaz., gives the following very interesting arrangement (Fig. 62):

This crossing was subjected to considerable use by both standard and narrow gage equipment, but there was not time nor justification for the installation of a special crossing frog, neither were there any movable or double-point frogs available. So it was decided to construct a crossing out of standard frogs and switches which were on hand. The crossing, as shown by the illustration, consisted of two No. 8 frogs and

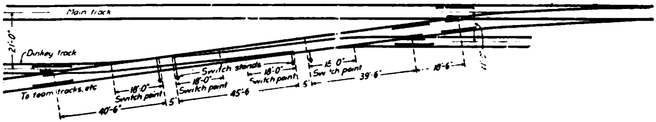


Fig. 62. Details of Crossing of Standard Gage and Narrow Gage Track Using Only Standard Frogs and Switches

four switch points operated separately with a switchstand for each point. The switch targets showed white when set for the normal position in line for side track movements.

A crossing watchman, who also acted as a switch tender, was kept on duty during the working hours of the contractor, and at night the crossing was locked clear for the side track. It would be possible to pipe connect such a crossing with the main track switch, thus eliminating the necessity for a watchman, and this would perhaps be advisable if traffic over the crossing were very light. In an emergency such a crossing could be used on main track by pipe-connecting the crossing switch points with the signals.

The crossing, as constructed, was installed by a

gang of 25 men in seven hours, and as there was no charge for material the entire cost amounted to only $35.

Frogs in a ladder track. Inexperienced foremen sometimes find it difficult to locate the frogs in a ladder track in such a manner as to avoid leaving kinks either in the ladder track or in the tracks which run parallel to the main track. The places for the points of frogs can readily be located in the following manner:—

RULE: Stretch a string along the gage line of the ladder track rail 4 ft. 8½ in. from the gage line of the frog in the main track, measured on the side towards

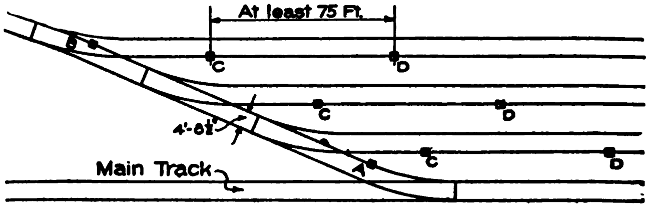


Fig. 63. Frogs in a Ladder Track

the proposed side tracks—(A B, fig. 63). Then set two stakes C D, C D, etc., in the gage line of the rail nearest main track for each of the parallel side tracks. These stakes should contain tacks accurately set and at least 75 ft. apart. Of each pair of tacks C D, the one nearest the ladder track, C, should be not more than 25 ft. from where you think the frog is to be. The desired locations of the theoretical points of frogs for the ladder track are at the intersections of the string A B and the lines given by strings stretched over the tacks at C D–C D, etc.

The above rule will work well where the two tracks diverge at an angle corresponding to the frog angle,

but where this angle of divergence is different from the frog angle in the main track, or when the tracks running from the ladder track are not parallel to the main track, these will meet the ladder track at a special angle and will leave the ladder track on a curve, or else will require a frog of special number, which can be ascertained by the following method:

To ascertain the number of frog needed. The lines in the diagram, Fig. 64, represent the rails of two tracks. Measure across between the track rails at the points marked A and B, each of which is at an equal distance from C, where the rails cross, then measure the distance, C B. Now divide the distance, C B, by

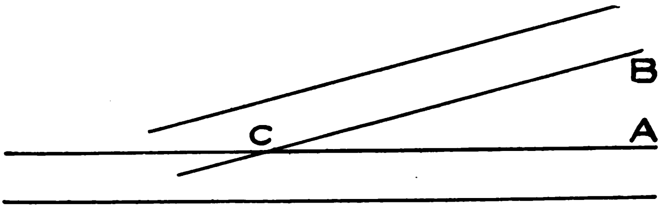


Fig. 64. Diagram for Determining Frog No.

the distance, A B, and the result will be the number of the frog required. Suppose the distance, A B, is twelve inches, and the distance, C B, nine feet; it would require a one to nine frog, or as it is generally called, a number nine frog. The distance, A B, may be measured where the rails or lines are only six or eight inches apart, but the result will always be the same in proportion to the distance from C to B. Where tracks are to run parallel with each other, it is best to gage the distance they are to be apart by measuring from the nearest rail of a permanent track adjoining, if in good line, or from the center of the main track in yards.

In ladder tracks the distance between frog points, where they are all of the same number, is approximately equal to the distance between track centers multiplied by the frog number.

XIX

USE AND CARE OF TRACK TOOLS

Tidy tool houses. Most railways furnish tool houses with ample room for a hand car and all the tools necessary for a section gang, and with a little pains on our part we can arrange them so that each tool may have its own place, and be kept there when not in use. By taking a look at a foreman's tool house a fair idea of his ability may be gained. If he has a tidy and well arranged tool house, with the hand car and tools all in good working order, you can rest assured that there is some well-kept track not far away.

Foremen are expected to send their tools to the shops to be repaired, or to be replaced by new ones whenever necessary, so there is seldom any excuse for having tools on hand which are not in working order.

There is probably a difference of opinion as to just how each tool should be used, but there is no room for argument on the proposition that there should be an individual system of use and care for track tools, and that the best should be given.

The Axe. The first thing needed for it is a handle, which should be snugly fitted, and firmly wedged in. Next, it should be ground sharp, and kept in that condition; it should not be used for anything but chopping or splitting.

Adze. It takes some practice to learn to use an adze properly, and leave the ties smoothly adzed. In adzing down old ties, cut deep enough so that the

edge of the adze will go beneath the flange of rail and thus avoid dulling the adze. When adzing ties on curves, great care should be exercised to adze them uniformly and to a proper depth, always keeping a lookout for stub spikes, or anything that may dull the tool unnecessarily. The adze should not be used as a hammer, nor for anything but adzing. A handle is very easily adjusted to this tool, but is easily broken if not handled properly.

Hand cars. Oil boxes should be frequently repacked, as the packing soon becomes filled with sand. Keep all boxings fitted snug; when they become worn, file or grind them down. Keep all keys tight, as well as all bolts and nuts. Do not let cogs mesh deep enough to grind. See that the driving arm is not too short or too long so as to throw one end of the walking beam too high and the other too low. Drop a little oil on all the bearings often. Do not use much at a time, but apply frequently. Care should be exercised when putting the car on and off the track. A little pains should be taken to instruct men in pumping a car so that they pump steadily and together, and in going up grade or against the wind to pump on the up stroke as well as on the down. Keep the car going at a brisk rate, for it is easier to keep it going in that way than it is to pump when the speed gets low.

Hand cars are in universal use, and a car which will give good service on an American road will be equally desirable and useful on any railroad. To be desirable a hand car should be light, speedy, strong, durable, and of simple construction, so that the section men can perform minor repairs without having to send it to the shop. With these qualities it will pay for itself in a year in time saved and useful work performed.

Several manufacturers make a specialty of building improved hand cars, any of which are preferable to

the "home made" ones which come from the railway shop.

Buda No. 1 Standard Hand Car. The following standard specifications apply to the car illustrated in Fig. 65:

Gage: Standard 4′ 8½″.

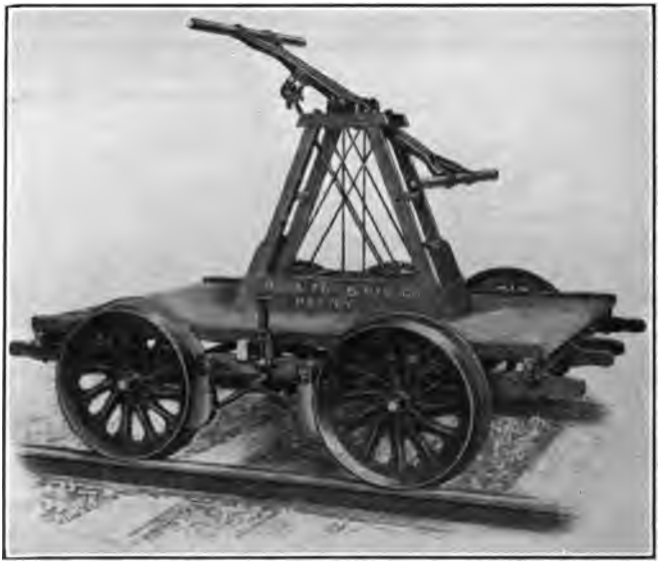


Fig. 65. Hand Car

Wheels: 20″ diameter, Buda pressed steel.

Axles: 1½″ diameter, open hearth steel. Taper wheel fit.

Weight: 525 pounds.

Gears: Regularly equipped with machine-cut helical gears. Can equip with cut spur gears, if desired.

Platform: 6 feet long by 4 feet, 5 inches wide.

Remarks: For roads having block signals with track circuit, this car can be insulated.

The modern type of section car is motor driven and effects very considerable economy, due to saving the time and strength of the men.

Cost of operating motor cars. Mr. J. L. Walsh of the M. K. & T. Railway says in Ry. Age Gaz. that in 1913 and 1914 this organization was furnished 10

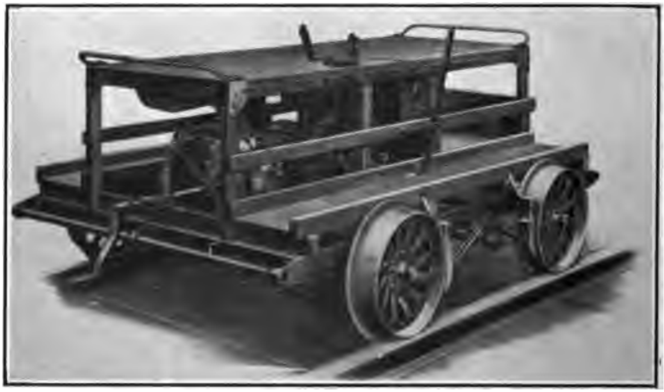


Fig. 66. Gasoline Motor Section Car

Fairbanks-Morse No. 32 motor cars at a total cost of \$2,444. These cars in 13 months made 80,465 miles, consuming 2,701 gallons of gasoline at a cost of \$256.63, with oil and other supplies costing \$75.61. The mileage was 29.9 per gallon of gasoline.

Upon putting the cars in service on the Kansas City division the number of sections was reduced from 16 to 12 of eight miles each. The total cost of track labor for 13 months decreased \$3,326.80, which he attributes to the use of these cars.

In proportioning the money saved he considers that the largest saving was going to and from work, since under ordinary conditions the cars will make a speed of 20 miles per hour, enabling the men to start to work fresh from 30 to 45 minutes earlier than they would on the hand car, and allowing them to work a correspondingly larger number of hours without greater fatigue. The total saving thus effected at 13,134 man hours amounted to $1,970.10, which will pay for the cars in 15 months.

Another advantage of the cars is that the foreman can leave most of his gang on a piece of work and go over his section with one man, but in doing this he ought to be very sure that he can get the car off the track with one man helping fast enough to avoid getting hit by a train.

The cars accommodate 10 men together with track tools and can handle the push car with from 25 to 40 ties without much trouble; moreover with the push car they can handle 20 or 25 men in extra gang work. Mr. Walsh also used these cars in bridge work. He had for this purpose a Buda motor car No. 19 equipped with a free-running engine, and he found that it was possible to eliminate four moves of the bridge outfit per month, the average move being about 25 miles.

Hand cars and speeders. Mr. C. E. Foreman has given the following valuable suggestions in Railway Engineering and Maintenance of Way.

"Most hand cars are manufactured with a view to light running, and consequently the majority of new cars when received are squared up and true. However, if not, they should be trued up by loosening the bolts which fasten the boxes in which the axle revolves, and moving one end of the axle forward or back to a position where there will be no tendency for the flange of any of the wheels to bind against

the rail when the car is moved forward on straight track.

"Flanges binding against the rail cause more hard bumping than any other single defect. When axles are in proper condition tighten the bolts firmly and see that they are kept tight. Hand cars should be tried out frequently to see if they are 'true,' as setting cars off and on the track, pushing them loaded

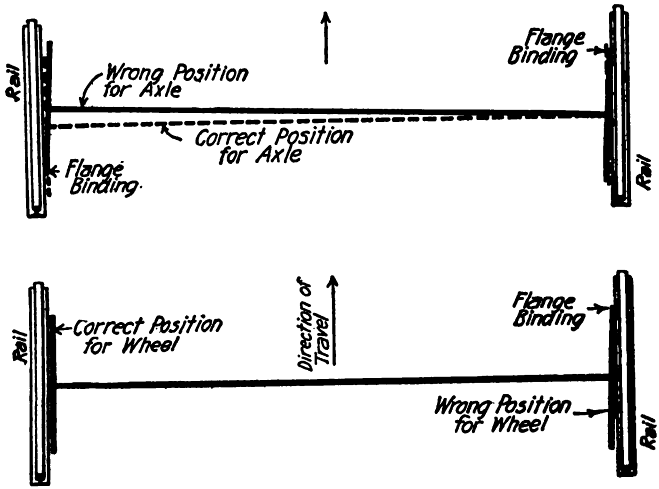


Fig. 67. Correct and Incorrect Positions of Axle

with tools over highway crossings, rough handling, etc., is very liable to loosen and move the boxes from their proper positions.

"Binding may also be caused by a wheel not running parallel to the track, although the axle may be in proper position. (See Fig. 67.) This, in a new car, is clearly the fault of the manufacturer and should be remedied in a shop. Binding occasionally

is caused by a crooked wheel or 'a wheel which has the snakes.' If the wheel cannot be straightened and trued up a new wheel should be obtained.

"Most handcars have their 'Front' and 'Rear' ends marked, and if the wheels and axles are properly trued up the car will always run lighter when placed on the track with the 'Front' end in the direction of travel. This is especially true when running around curves. All wheels except the 'loose wheel' should be keyed tightly to the axle and not allowed to work loose or get out of position so that they bind. The loose wheel should be painted a conspicuous color or otherwise marked so as to be readily located, and then the car can be turned by lifting the end opposite that which the loose wheel is on. Proper lubrication of the loose wheel makes pumping easier around curves on account of the unequal distance traveled by the inner and outer wheel.

"Next in importance to binding comes grinding. Grinding in the bearings may be due to lack of oil, but it is safe to say that more frequently it is due to dirt and sand in the bearings. Hand cars should never be used to transport sand and gravel, but in case it has to be done the bearings and oil holes should be protected from all dirt and sand.

"Exterior surfaces around bearings and oil holes should be kept clean of oil and grease and the consequent accumulation of dirt. Never oil the cogs of the gear wheels in either a speeder or hand car. While good clean oil will reduce friction between the cogs, the oil will also cause an accumulation of dirt, sand and cinders, and before long the teeth will be choked with a hard, gritty mass that will cause the car to drag, even down grade.

"Bolts and screws holding the frame together should be kept reasonably tight, but should never be turned excessively tight, especially where the heads or nuts

and washers sink into the wood. Unless the nuts on the underside of the platform are tightened occasionally, especially those with which oil comes in contact, they will jar loose and the lower half of a bearing box may drop off unnoticed.

"The care and operation of speeders (three-wheel velocipede cars) requires more attention than of heavier four-wheel handcars. Binding here is more frequent and, since usually only one or two men are pumping, more noticeable. Fig. 67 represents the conditions ordinarily found. The front wheel on the load-bearing side (right side) should be very slightly turned toward the rail, as shown, exaggerated, in the lower view of Fig. 67, but should not bind enough to make pumping difficult. This position of the wheel is necessary in order to make certain of the car keeping the rails when going around curves to the right, especially if the curvature is sharp. If the speeder is to be used only on tracks having very light curves the wheel can be advantageously placed parallel with the rail and it will be found that the car will keep the rails unless there are other faults, such as sprained or badly worn frame or parts, etc.

"Speeders, which are necessarily built light, should be handled with more care than heavy handcars, as shocks and derailments are liable to cause sprains or breaks. While these damages may be repaired, it is usually found that the car does not run as easily as before, on account of failure to restore exact former conditions. Rough usage in loading and unloading speeders for shipment is frequently the cause of a car running heavy. Personal attention to this feature, instead of leaving it to the baggageman or freight handlers, will lessen the labor of pumping.

"A speeder which is used regularly should be cleaned periodically. The ball bearings and retainers should be removed and thoroughly cleaned with kero-

sene. Examine the bearings for rough spots and if found replace with new parts. When replacing, pack the ball bearings in a generous amount of clean vaseline.

"Under heavy loads or usage a grinding or 'screeching' will sometimes develop in the wheel bearings, although they may be well oiled. This denotes a worn

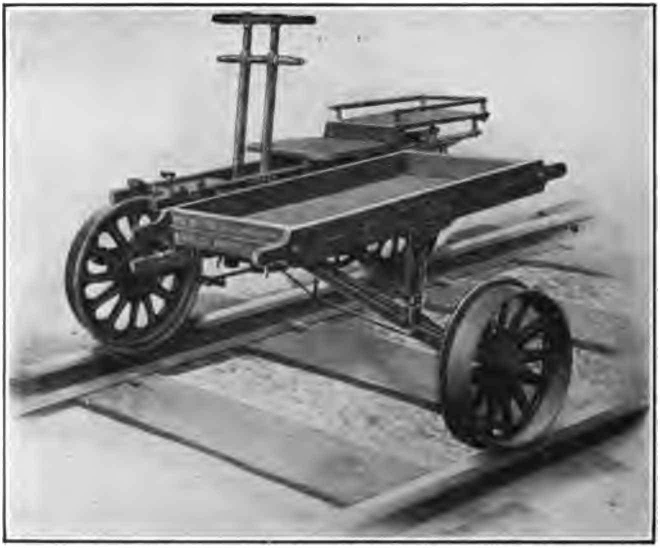


Fig. 68. Single Speeder

retaining cup or a broken ball bearing. These should be replaced at once, else the damage will spread to all the ball bearings, the cups and the axle, besides increasing the labor necessary to propel the car.

"Attention to the details mentioned, by the man who has considerable pumping to do, will result in the saving of a great deal of unnecessary hard labor. The

writer has found this to be true by trying it out. In one season from March to September, inclusive, the writer has, with a partner, covered over 2,500 miles on a No. 3 velocipede car. By keeping the car in proper condition a mileage of 56 miles was made in one day, and 65 miles the following day; these distances being over ordinary track and grades, including the climbing of a long divide; one day facing a 'head-wind' and the following day pumping with the wind.

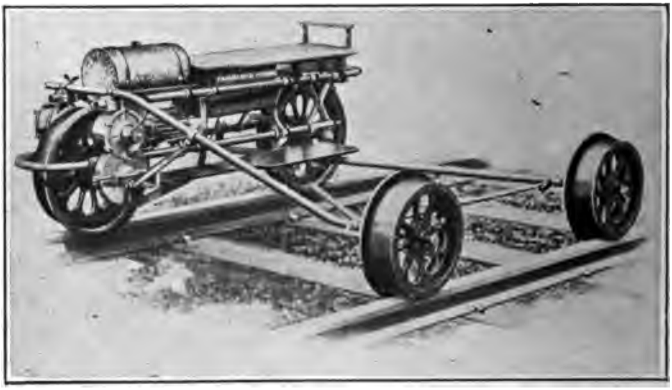


Fig. 69. Gasoline Speeder. Weight 320 lbs.

"The 'head-wind' always has been and always will be the pumper's worst enemy. We cannot control it; but we can control the condition in which we keep the hand cars and speeders which we pump every day."

Speeders are made with three or four wheels, arranged to be propelled by hand as well as driven by mechanical motors. This latter mode of operation has gained in favor of late years and is particularly advantageous for roadmasters who have to cover long distances, or for inspection trips where considerable

speed is required, and where the working of the levers of a hand car would interfere with the view of the inspectors.

Claw bars. Nothing will cause more annoyance than a poor claw bar, one on which claws are too far apart at toe or close together, neck not properly bent, heel out of proportion to claws, and so on. Most of these things can be remedied at shops. When they are sent in to be remedied a letter and a sketch should be sent along if possible, showing what changes should be made. A good many of the claw bars now in use would be more valuable to the company in the scrap pile than anywhere else.

Cross cut saws. Strict attention should be paid to filing and setting saws. They should be carried on the car and kept in tool house in such position that the teeth will not come in contact with other metal tools. Men should stand squarely opposite each other when sawing, each dragging the saw toward him, but never pushing the saw. A saw in good running order does not need any crowding.

Cold chisels. A full complement of these should always be kept on hand. It is the custom when using a chisel to stick any kind of a hard wood piece into it for a handle, but it pays to fit good handles to chisels, as well as other tools, so that you will not have to stop to insert handles while cutting a rail. A great many chisels are spoiled by not being properly held. If a chisel has good temper and is not broken too badly it is better to grind it down than to send it to the shop; but if it cannot be ground down profitably, it should be sent to the shop at once, not kept around the tool house.

Track gage. The gage should be made to serve a better purpose than merely to mark the standard distance between the rails. A wooden gage may do well when ends are well bound with iron, but a metal gage is

better. There should be a fork on one end to prevent the gage from falling on its side when spiking, and also to square it across the track. This end should be fastened solid, either welded or screwed and riveted to the end of a wrought iron pipe. On the other end of this pipe, the single end of the gage, the lug should be adjustable; it should be screwed up tight on the pipe when standard gage is desired, and lengthened out as necessary when gage is widened on curves. A small thumb screw through the adjustable lug, with a narrow seat planed on the pipe will hold the lug in place, and this screw seat can also hold oil to keep thread from rusting and turning hard. The lugs should be of the same size on both ends 1¾ inches wide and 1⅜ inches deep. This would be satisfactory under all circumstances and is simple; strong with no delicate parts to break; will adjust to widen gage on curves; the width of the lugs is standard guard rail distance; the depth of the lugs will show if blocks in switches are clear of wheel flanges, allowing one-fourth inch extra as flanges on wheels are generally 1⅛ inches deep; the wide lugs on double end of gage will fit snugly between wing rail and point of frog and stay there, while the single end will show where to set the guard rail regardless of how wide the track is. This gage will pay for itself in the saving of wear of frog points alone, besides other services that it can render while gaging track on curves.

Lining bars. Some of the bars in use are of iron and are too heavy. A steel bar weighing about twenty pounds, with chisel point on square or bottom end of bar, and sharp pointed at small end, is about right. Lining track is probably one of the most difficult things a foreman has to do. Where track has just been raised, take only enough men and bars to move track easily. Don't let men stick the bars in the ground at too great an angle; if they do they will raise

the track when they throw it over, and if the ballast is sandy some of it will run under the ties and spoil the surface. When lining track where it is hard to move, bars should be struck firmly in the ground before heaving on them, for if one bar slips all the other men have to wait while that one is being replaced. Men must always pull together, and always be ready when the word is given; the foreman should keep as far back as he can, to see well and avoid putting swings in the track. Some of the little defects can be taken out at short range.

Lanterns should always be kept in perfect order, for you never know at what moment you will need them, and you are always in a hurry when you do. The lanterns usually furnished are good to use for signals, but give little light to work by. A couple of engineer's torches will give more light than a dozen lanterns. Every trackman should know all lamp signals thoroughly, and when placing danger or slow signals care should be taken to set them in plain view of an approaching train. Be sure to have them out the full distance required by the book of rules. If you err at all, be on the safe side. It is a short job to place signals, and serious accidents will be prevented often if they are put out properly. If you have any doubt about the stability of a piece of track, don't hesitate to use your signals. Be on the safe side. Lanterns, after being used, should have the oil taken out and put back in the oil can. Clean the globes, trim the wicks and set them in a safe place. If lanterns remain a long time without use the wicks should be changed or they will not burn well. When putting out lanterns as danger or slow signals, be sure that they are in good trim with plenty of oil. Signal oil gets too thick if it stands very long in small cans. When it does not burn well add kerosene to it. A few extra globes should always be kept on hand.

Spike mauls. About eight pounds is the right weight. Select the straightest handle for this, fit it snug and wedge it tight. If the eye is not straight in the hammer, which is often the case, file it out as nearly straight as possible with a rat-tail file. If face of hammer gets too rounded, file or grind it down. To drive a spike properly, stand at side of rail and start the spike perpendicular to the tie; never allow it to slant under the rail. A spike may be leaned a little from you when started, but the second blow should straighten it up. Stand with heels close together, use full length of handle, and give long, swinging strokes when spiking.

A shovel is the tool the trackman uses most and the incorrect use of it causes him to waste more time than in almost any other way. Therefore it is necessary for him to know some of the principles governing its work, and he should be continually on the alert to apply those principles in his daily practice. Most men think that shoveling is a perfectly easy, perfectly natural, and perfectly simple thing to do, and so it is when it is done without regard to the economy of the work or its quality; but when both these things are considered, shoveling is one of the most difficult of processes to perform properly. Hence, a brief reference to some of the principles involved in it will not be amiss in this book.

In order to accomplish the most work in a day, a man must perform the smallest amount of unnecessary muscular effort, to do which each motion should have the right direction with only the necessary amount of force. Now, in shoveling, two or three principal operations are performed. In the first place, the shovel must be pushed into the material or under the material to be lifted. Secondly, the man must raise the shovel and with it his own body, get ready to throw, or swing the shovel back, and next he must throw, for-

ward or side-wise, the shovel with its load, and a part of his own body also. Finally, he must stop the shovel and allow the load of the shovel to go on its way to its intended place. These operations may be listed as follows:—

1. Penetration
2. Elevation.
3. Swing-back.
4. Throw.
5. Recover.

It is clear that for some of these operations, certain kinds of shovels are particularly adapted, and for other kinds of operations other kinds of shovels are better. For instance, for penetrating tough ground in digging ditches, a square tamping shovel is one of the worst tools that can be used. Its cutting edge is not particularly sharp, it is wide and there is a poor place on it for a man's foot to push on. The average laborer will accomplish less than half as much work in digging ditches with a standard track shovel as he can with a round pointed shovel of proper size. It is thus evident that when the work to be done involves penetrating tough material, a penetrating shovel should be used rather than a tamping shovel. It is also clear that for throwing dirt, for instance, there are large shovels and small shovels to be used for heavy materials and light ones. The very large shovel should not be used for heavy material, nor should the small shovel be used for light material. If you give your men shovels which are designed for handling soft coal and they have to use them to throw iron ore the men will either stop work entirely or else in a short time they will become so tired as to very greatly reduce the day's output. On the other hand, if you give a man a standard track shovel and set him to work shoveling sawdust, his strokes will be perhaps a little faster than if he were shoveling dirt, but they will not

be enough faster to make up for the tremendous deficiency in the weight of material on the shovel, so that in the same amount of time he will throw perhaps a third as much sawdust as he would if he had a proper shovel for the purpose.

A most important feature in the economy of shovel work is the length of the shovel handle. If a man were to raise his body up and down, bending forward and bending back, without doing any other work at all, at the end of a whole day of that sort of thing he would be very tired without having accomplished anything. In working with a short-handled shovel, this is to some extent just what he does, with a great deal of effort. Whenever he lifts a shovelful of dirt he lifts several times that weight in his own body, and the weight of his own body that he lifts is just as tiresome to him as the weight of material on the shovel that he lifts, plus the weight of the shovel itself. Now, with a long-handled shovel he can stand up almost straight and with very little bending of his back and almost no bending of his hips, he can throw his shovelful of material without doing much of the unnecessary work of lifting his body. A great many men, especially track laborers, are accustomed to work with short-handled shovels and do not like to use long-handled ones when they are first given them. But after they have been trained to the use of long-handled shovels, especially for deep trench work, shoveling into a wagon, or for any purpose in which the delivery point is above the height of the waist, they take very kindly to the long-handled shovel, and in a day's work will accomplish a great deal more, generally speaking, than with a short-handled tool. When mixing concrete by hand the material can be lifted much more easily if the shovels are square pointed and are shoved along a platform, preferably of sheet iron or boards laid lengthwise of the movement of the shovel. When loading into cars

from a platform, whenever possible the men should work parallel with the planks of the platform; when working across them the edges of the shovel stick at the edges of the plank and can account for a surprisingly small output of work.

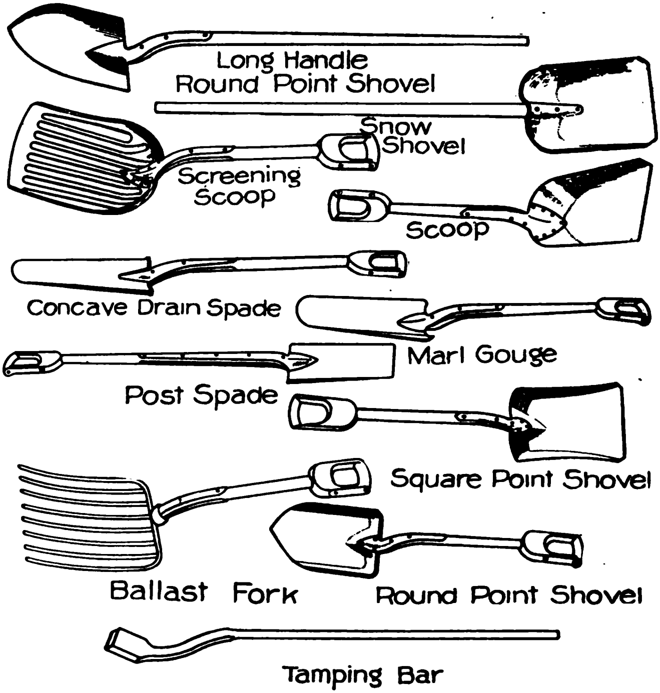


Fig. 70. Various Types of Shovels

The foreman should see to it that several kinds of shovels are kept in the tool house, and he should make a practice of timing his men by counting how many

shovelfuls they throw per minute. In this way he will soon be able to become an expert on economical shoveling. To accomplish this result it is not necessary to drive the men or to try them with the wrong sized shovel in order to determine the amount of work accomplished. The proper selection of tools is always appreciated by the men and they will always work more willingly, more intelligently and more effectively with proper tools. For ordinary average shoveling in earth a shovel which carries about 20 lb. of material is about right; for high lifts or very long casts, one size smaller than this should be used.

Fig. 70 gives an idea of the various types of shovels most suitable for different kinds of work.

Tamping bars should be made of seven-eighths in. iron or steel, length 5½ ft., sharp-pointed at upper end, have a tamping face four inches wide, and five-eighths inch thick, and weigh about 14 lbs., the neck bent so that the tamping face will be in right position when bar is held at an angle of about 45 degrees. When tamping face gets too thin send to shop to be refaced. Always be sure to remove enough dirt so that the tie can be well tamped; reach under the rail so that all the space under the tie will be tamped. Never slight this work nor allow the men to do so.

Track flags. Always have the flags with you, and always place them at the extreme limit required by the book of rules under which you are working.

Always send a trusty man to do the flagging. Flags when not in use should be encased in something that is water proof.

Tape lines. It often happens that a cloth tape line, after being wet two or three times, will shrink, and be too short; therefore measure them once in a while and see if they are accurate. Of course it is best not to get them wet, but sometimes it cannot be avoided. Steel tapes are not subject to this difficulty but are

liable to rust and must be kept oiled. Have a box to keep the tape line in when not in your pocket.

Track level. When surfacing track never try to get along without the level, but try it every day it is used to see that it is in correct adjustment. A good track level is one made of wood, 1½ inches thick by 3 inches wide, bound with iron strap at one end, and the other end having an iron or brass cap fitted over it and an iron standard 5 or more inches long through it; standard to be one-half inch square and graduated to one-eighth inch. Standard should slide easily either way, and have a set screw to hold it at any desired place. The end with the standard will, of course, be the heavier, and the handle should not be in the center, but should be placed so that the level will balance when

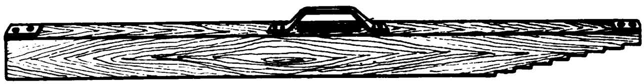


Fig. 71. Track Level

picked up. The track level should be used continually, especially on track which was never ballasted, or which was surfaced hurriedly without using a level. If you have surfaced a piece of track to a perfect level, then you can sight the depressions in the surface without using the spirit level when going over it a second time if the track has not become rough.

Section foremen in charge of new track should make it their business to improve the line and surface as fast as possible with the force allowed them, before the track settles or the ballast becomes a solid mass. While the ties and rails are new is the time to make a good track.

Track wrenches. Each section should have as many track wrenches as there are men in the gang. It takes a little practice to use a wrench quickly and handily.

The nuts should be well tightened and then hit with the hammer and tightened again. Where nutlocks are used nuts will not need to be as tight as where there are none. Wrenches should be made of one

Fig. 72. Typical Track Jack

piece of steel, and have four sides to the jaws, so as to fit square or hexagonal nuts.

Monkey wrenches. One should go with every hand-car. Don't use it for a hammer; keep it in good working order to tighten nuts.

Drawing knives and hand axes are very handy for putting in new handles and are often useful when making repairs around tool houses or other buildings. They need to be kept very sharp and should have a special place in the tool house.

A grindstone is a most necessary tool and should be turned steadily and tools held square to avoid wearing the face of the stone unevenly.

Track jacks. Every section foreman should have a track jack along with his other track tools, and he should always carry it with him on the hand car, and have it ready to use whenever it is necessary to raise track. A good track jack is one of the best and most economical tools that can be used on a railroad.

There are few things that look more ridiculous than three or four men making futile efforts to raise a rail with a long bar or track lever and a block of wood which is either too high or too low. The ingenuity or ignorance of the whole gang is displayed a score of times during the day, whenever the block will not do to raise the track to the proper height, and valuable time is lost in trying to find a stone, a chunk of wood or a spike to increase the leverage, and which is seldom or never thought of until the moment it is wanted. Sometimes the spikes are pulled out of one or two ties in every rail length, and the track is raised from the tops of the ties. This method also causes a considerable loss of time, pulling the spikes and respiking the ties, besides the injury done the ties when the old spike holes are left open to rot the wood. Raising track with a lever pulls the rails out of line much more than raising it with a jack, and makes it more difficult to put back into place, often loosening the spikes where the ballast is heavy, and the track is laid with soft ties.

In order to avoid accidents when track is being raised, the track jack should be set on the outside of

the rail. In this position the pilot of an engine, if it should strike the jack, will knock it clear of the rails. But there is no necessity of using a track jack immediately ahead of the passage of trains, or when

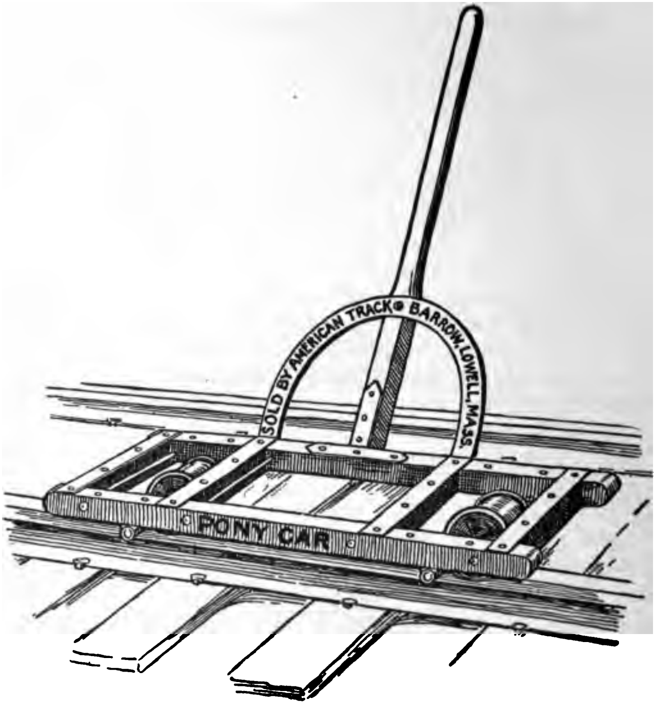


Fig. 73. Pony Car

they are due at that point, and the men can be employed at other work for the time. Track jacks placed inside the rails which could not be removed in time, have caused the derailment of numerous trains. Al-

ways properly protect yourself with flags when using a jack

Rail benders and jim crow. Almost every section has more or less kinky rails, and with these tools the joints can be straightened where they are crowded out too much. First, pull the spikes and plug the holes

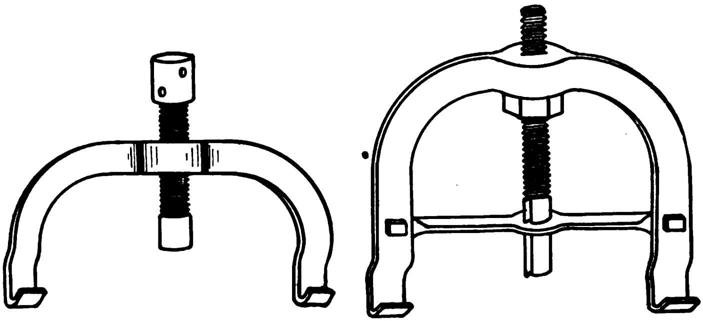


Fig. 74. Jim Crow Rail Benders

where the kinks occur, then use the rail bender or jim crow and the track will present a much better appearance. These are also very handy in cutting rails. Mark the rail with chisel, put on the "bender" and break it.

Ratchet bits. When drilling holes the bits should not be crowded too hard, as they are generally highly tempered and are likely to break at the point. See that the bit is in the ratchet straight and fits snug.

Ratchet drills. Keep them as free from grit and dirt as possible. When placing them for drilling a hole, be sure to set them straight, so that there will be no crooked or misplaced hole.

Standard track drills have supplanted the use of the ordinary ratchet drills to a great extent now and there are numerous styles on the market.

Striking hammer. Every section should have one of these. Twelve pounds is about the right weight, and the handle should be a little shorter than for a spike hammer. Always use the striking hammer for striking the chisel; a spike hammer should never be used for this.

Sight boards and spike pullers. Every foreman should have some kind of sight board or blocks to use

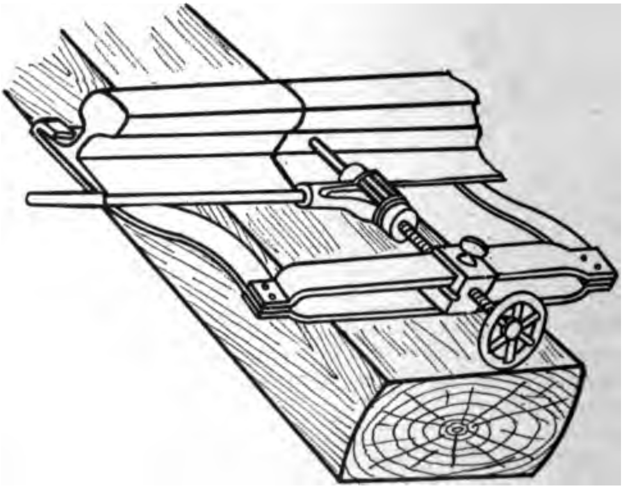


Fig. 75. Ratchet Drill

when taking out long sags. Another tool which is very handy is a short spike puller for pulling spikes where the claw bar cannot be used. In lieu of something better, a short pinch bar, such as engineers or car repairers use with their jacks, can be used to advantage. Bend them a little more at the heel and they will start spikes fairly well. However, the spike

pullers offered by manufacturers are far better and handier.

Oil for wooden handles. All wooden tool handles should be well oiled before being used; it prevents sea-

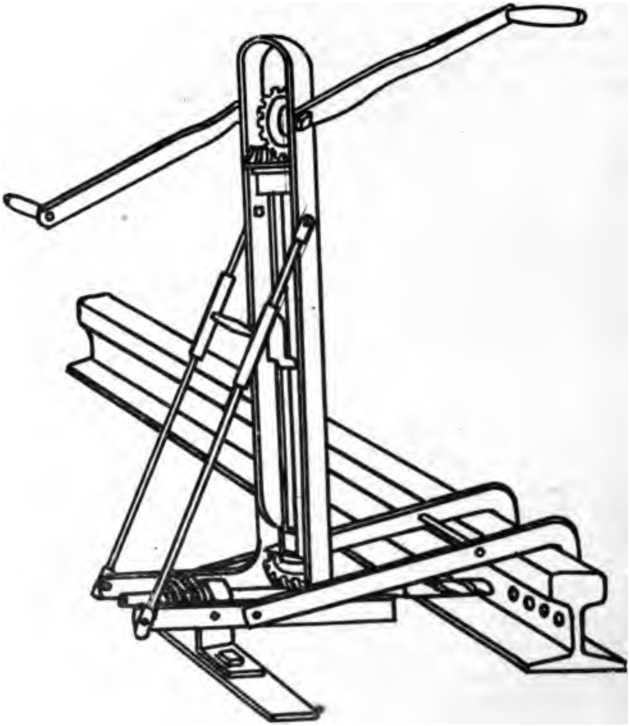


Fig. 76. Standard Track Drill

son checking to a great extent and causes them to wear smoother.

Importance of having tools ready for use. One of the most important things in railway service is time.

Time represents so much capital invested by the company, and to make this investment pay dividends you must know how to use and care for the tools you have. Make a practice of handling tools to the best advantage, so that in case of emergency you may be prepared for anything that turns up. Think for a moment of the loss and inconvenience that is caused if one of the main lines of one of our great railway systems is blocked for a few hours. In case of a wreck or washout, or any other accident that may happen to a railroad, and a big force is called out to repair it you can make yourself of valuable service by knowing how, when and where to use tools, and have them distributed so that you do not have too many at one place and too few at another. Have everything arranged so that the most work may be accomplished in the least possible time.

XX

TIE PLATES

Saving in tie renewals. It has been found that when the ordinary soft wood ties, such as white pine, cedar, red wood, chestnut, tamarack, and cypress, are placed in track where traffic is heavy, the fiber of the wood will be crushed, abraded and destroyed by the wave motion of the rail, long before they would have to be removed on account of natural decay, as described in Chapter IX.

The natural life of the soft woods, when used as ties, averages ten or twelve years; but they have been known to be destroyed in six months under peculiarly severe conditions, and under ordinary conditions within a period of from two to four years. Hence, the railroads of America have not used soft wood ties, except under the lightest traffic, until the tie plate came and proved its tie preserving qualities. Since then it has been demonstrated through practical experience that by the use of a properly constructed tie plate the utility of these soft ties may be extended to their full natural life of twelve years or so, and that, when they are treated with a wood preservative and placed in track with tie plates, they will probably last much longer. From this it will be seen that tie renewals on roads using tie plates on soft ties will be much less than the requirements where no tie plates are used.

The density and compactness of the wood in oak and yellow pine ties is sufficient to withstand the de-

structive action of the rail on straight track for a period often equal to their natural life. On curves of over three degrees, it has been found necessary to use tie plates to preserve the hard wood ties to the limit of their natural life.

Avoid adzing in maintenance. The load upon the rail due to the wheels traveling over it is both vertical and lateral, according to the surface of the track, mak-

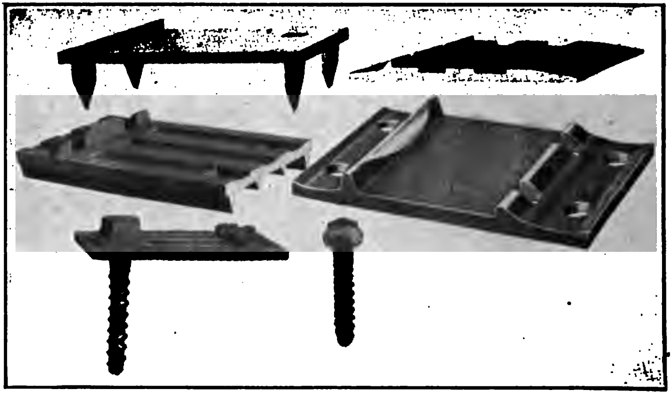


Fig. 77. Various Types of Tie Plates.
(1) The Goldie Claw Tie Plate
(2) The Harriman Type
(3) Dilworth Special Shoulder-Flange Plate
(4) Lackawanna Hook Shoulder Plate with Screw Spike
(5) Newhall Plate

ing the strain greatest on its outer edge, and causing the outer rail flange to cut down into the fiber of the wood more quickly than the inner.

When the rail assumes this canted position the gage is widened; this increases the lateral sway of trains which requires that track men draw the spikes, adze the tie beneath the rail to a level surface and then re-

spike. This adzing requires the tie to be tamped and raised by an amount equal to the depth of adzing, all of which can be saved by the use of a tie plate.

Types of tie plates. Some of these are illustrated in Fig. 77. The main dimensions of the Goldie Claw Tie Plate are as follows:—

Shoulder	$\frac{1}{4}$ and $\frac{3}{8}$ inch
Length	7, $7\frac{1}{2}$, 8, $8\frac{1}{2}$ and 9 inches
Width	5 inches and up
Thickness	$\frac{5}{16}$ inch and up

Those of the Harriman type:—

Shoulder	$\frac{1}{4}$ and $\frac{3}{8}$ inch
Length	$7\frac{3}{4}$, 8, $8\frac{1}{2}$ and $8\frac{3}{4}$ inches
Width	6 inches and up
Thickness	$\frac{3}{8}$ to $\frac{1}{2}$ inch

The Dilworth special high shoulder type for use with A. R. A. rail, where two spikes are used on outside of rail:

Shoulder	$\frac{1}{2}$ inch
Length	8, $8\frac{1}{2}$ and 9 inches
Width	5 and 6 inches
Thickness	$\frac{3}{8}$ inch and up

This type of plate can be furnished without the depressions in the top.

The Lackawanna Hook Shoulder type of plate as illustrated measures $11\frac{1}{2}'' \times 7'' \times \frac{3}{4}''$; weight seventeen (17) pounds, for one hundred and one (101) pound rail with $5\frac{3}{8}''$ width base, flat rail base seat. Central line of plate is ex-central to rail. Forty-eight per cent. (48%) of plate bearing on inside and fifty-two per cent. (52%) on outer side of central line of rail. Holes punched for four (4) holding (standard screw) spikes, and two (2) guard (common) spikes.

Fig. 77 shows a type of plate with screw spike.

Another type is the "Erac" combined rail anchor

and tie plate (Fig. 78). This combination consists of:—

1st. A rolled steel double shouldered tie-plate. 2nd. A round corrugated steel pin working on an angular plane. (A) Section of rail. (B) Tie-plate. (C) Shoulder with obtuse angle on inner surface. (D) A round, corrugated steel pin.

Fig. 78. The "Erac" Combined Rail Anchor and Tie Plate

The pin moves in angle in the direction of the creeping, expansion or contraction. The greater the tendency to creep the more firmly the pin locks.

The "Lundie" plate, of still another type, is shown in Fig. 79. An inspection of test rails in the main track of a trunk line road indicated the effect secured by the use of this plate and was described in the Ry. Age Gazette as follows:

"New 100-lb. A. R. A. type A rails were laid on parallel tracks on a 5-deg., 40-min. curve carrying a heavy freight traffic one year before the inspection referred to. The Lundie tie plates were placed under

the rails in one track while ordinary flat plates were used in the other track. The superelevation of the high rail was standard. The usual wear of the rail head was found on the track laid with flat plates as indicated in the accompanying drawing reproduced from measurements made of the rail head at the time of inspection, while the rails laid on the canted plates

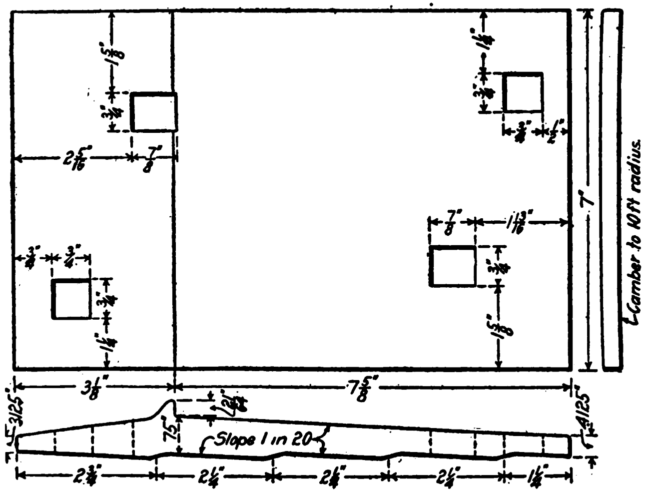


Fig. 79. Details of a Lundie Tie Plate

show a slight wear uniform over the surface of the head. These plates are also in use in about 20 other installations in which it is said that similar results are being secured.

"This tie plate is designed to support the rail at an angle of 1 in 20 with the horizontal, equivalent to the angle of coning on car wheels so that the surface of contact between the wheel and the rail and the rail and the tie plate will be perpendicular to the direction of

application of the wheel load. In addition, the underside of the plate is given a bearing on the tie, a large part of which is perpendicular to this stress by a series of stepped surfaces, each of which has an angle of 1 in 20 with the horizontal. The advantages claimed for this method of support in addition to the reduction in wear on the rail head are a decreased tendency of the rails to spread, a lessening of the internal stresses in the rail due to loading the head centrally and a reduction in wear on car wheels equivalent to that on the rail head. The plate is cambered on a 10-ft. radius parallel with the axis of the rail so that it does not present a sharp edge under the base of the rail when

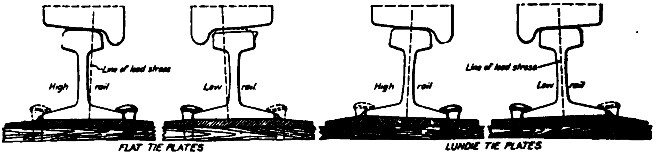


Fig. 80. Cross Sections of Rails in Adjacent Tracks after One Year's Service on Flat and Lundie Tie Plates, Respectively, Showing Difference in Wear on the Heads.

the wheel load passes over it. It is claimed that this feature gives the added advantages of an easy riding track in that the rail adjusts its bearing on the plate, and an absence of rattling owing to the fact that the plate does not tilt under approaching or receding loads. The plate is said to perform its functions equally well on hard and soft ties, as on a hard surface which does not compact readily the camber will allow complete resilience under load, the flattening of the plate producing stresses within the elastic limit of the metal."

Surface. Where no plates are used the old ties must be adzed for several years before they are to be taken out of the track to maintain the rail level, and

when so adzed they must be raised to restore the surface, hence the roadbed beneath them is disturbed and requires filling in and tamping under the adzed ties, leaving such portions of the roadbed soft and yielding, while other parts are thoroughly compact and rigid, the result being a bad riding track.

When all ties are protected with tie plates these conditions do not occur, the tie plate preventing the cutting of the tie, and consequently the necessity for adzing and retamping, leaving the roadbed uniform, and making a smooth riding track. Thus a great saving in track labor is accomplished.

Gage. The lateral force tending to throw the rail to a wider gage is resisted by the outer spike only, which in its turn is supported by the fiber of the wood behind it; but when a tie plate with shoulder is used the widening of gage can then take place only if both spikes together with the plate move laterally, which is almost impossible. Hence we have the full resistance of both spikes, plus that offered by the plate itself, to prevent widening of gage, giving increased safety in operation.

Holding rail vertical. Of the two forces acting on the head of the rail, the vertical one is by far the greater. With the use of rail braces these two forces are transmitted to the tie as follows: The small lateral force is transmitted directly to the rail brace and through it and the spikes holding it to the ties, but the much greater vertical force is transmitted to the tie directly at a point near the edge of the outer rail flange, and this force the rail brace is not designed to, and does not resist, with the result that the tie is cut out and the rail brace is canted. By the use of the tie plate the much greater vertical force is resisted by the plate and is distributed over the tie. The much smaller lateral force is resisted by the inner and one or two of the outer spikes, according to the

necessity of the case. This fact has become so well established that after a trial of tie plates practically all railroads in the United States having the sharpest curves and heaviest grades have abandoned the use of rail braces and adopted tie plates in their stead. The use of the tie plate on curves insures a normal position of the rail, prevents the rail from rolling, which, in turn, insures a true gage.

Necessary features of a good tie plate. A good tie plate must become part of the tie into which it is bedded, in order to avoid any movement between plate and tie. This may be accomplished by longitudinal flanges on the plate entering the tie parallel with its fibers, and compressing them without injuring them, the reactionary pressure of the fibers upon the

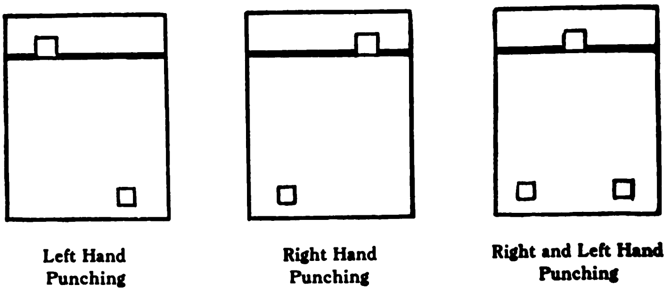


Fig. 81. Methods of Punching Tie Plates

flanges of the plate making the latter practically a part of the tie. A well-known illustration of this fact is that when an axe is driven into a piece of timber parallel with the grain of the wood, it remains firmly wedged in, while if cut across the grain it has no grip at all, and is easily worked loose.

A disadvantage of the use of flanges is that they force the fibers of the wood apart and leave spaces into which water may enter and start decay. This diffi-

culty is responsible for the abandonment by some roads of this type of plate.

A good tie plate must have sufficient strength to distribute the load from the rail to the outer ends of the plate without bending, for if this is not the case the plate buckles, loosens from the tie and destroys the fibre of the tie rapidly. A point to be guarded against is the using of too much metal in the plate; if this occurs it will work itself loose from the tie by its own inertia and destroy the wood fibres. The flanges used on some plates act as girders and distribute the load on the rail to the extreme end of the plate in a much more economical manner than if the plate is increased in thickness.

There must also be provision made for sand to escape from the top of the plate; otherwise the grit getting between rail and plate will gradually destroy both rail and plate; but with the proper means of escape, such as channels or ducts, it has been found by experience that it has but little effect upon the plate.

Information required when ordering tie plates: Weight and section of rail, Width of rail base, Style of plate, Length of plate, Width of plate, Thickness of plate, Height of shoulder, Size of spikes to be used. Number of holes required—if three holes, give distance between centers of inside holes, State whether joint or intermediate plates are wanted. On joint plates the following information is also required: Stagger of holes in angle bars. What is the width out to out of angle bars? Should shoulder of joint plates abut against rail or against angle bar? If against rail, send drawing showing clearance between angle (or splice) bar and rail.

XXI

WRECKING

The first duty of a track foreman, when he receives notice that there has been an accident and he is wanted, is to collect his men and take his hand car and all his portable tools, even those which he thinks he is not likely to use. He should not go short of tools expecting that other foremen will have enough. The other foremen may think the same thing of him and valuable time will be lost.

On the ground. When the foreman arrives at the scene of accident, he should proceed immediately to do whatever work, in his judgment, would contribute most to putting the track in a passable condition for trains, notwithstanding the absence of his superior officer, who may not be able to reach the wreck for several hours. If the track is torn up, and the cars do not interfere, put in ties enough to carry a train safely over where you can. If the rails are bent out of shape secure some from near by if possible. If this cannot be done, get as many as possible of the damaged rails to their proper shape, and spike down in the track.

If a small bridge or culvert has given way, crib it with ties until you can cross it with track.

To square a car truck. If one or both trucks beneath a car should leave the track at once and turn across it, as is often the case, uncouple from the car and hitch a switch rope to the corner of the truck and to the draw head of the car next to the one which is off

the track. Then pull the truck into a position parallel to the track, after which it can be put on the rails with the wrecking frogs.

If the car should be loaded very heavily, it may be advisable to raise the end with jacks before squaring the truck.

Cars off on ties. When cars have got off the track, and are still on the ties, it is best to put blocks or ties between those in the track to keep the wheels from sinking between the ties. By doing this at once, before attempting to put the cars back on the track, considerable time and labor will generally be saved.

Oil the rail. If an engine or car mounts the outside rail of a sharp curve, and persists in running off the track, oil the rails thoroughly where the most trouble is experienced. This will generally allow the engine or car to go around the curve without leaving the track.

Very rusty rails on a curve track which has not been used for some time often cause the wheels to mount the outside rail, the surface not being smooth enough to allow the wheels to slide.

Car trucks in the ditch. When the car trucks are thrown some distance from the track in a wreck, the quickest method of putting them on the track again, if you have no derrick car, is to take bars and turn them almost parallel to the track, but with one end a little nearer to the track. Hitch a rope to this end of the truck, and to the engine, or the nearest car which is coupled to the engine, and the truck will pull onto the track easily, if there is nothing to obstruct its passage.

To turn a car truck on soft ground. When car trucks are sunk in soft ground at a wreck, and there is no derrick car or other lifting apparatus at hand, a good way to handle them is to place a tie cross-ways in the ground, about four or five feet from the truck;

then place two more long ties or timbers, with their centers resting across the first tie, and their ends in front of the truck wheels. The truck can then be pushed up on top of the long ties as if on a track. When it is centered over the bottom tie, the truck can be easily turned to run in any direction.

To put a wrecked gravel plow back on cars. Trackmen in charge of a ballasting outfit, if they are new at the business, are often at a loss to know the quickest way to put a plow back on the cars if it should accidentally be pulled off. The best way in such a case is to roll the plow or pull it with the engine and cable into the same position on the track that it would occupy on the cars; then raise up the point of the plow until you can back the end of a car under it, hook the end of the cable to the plow, block the car wheels and pull the plow upon the car with the engine.

Sliding a car on a tie. If the rear truck of any kind of a car should by accident be derailed, broken, or rendered useless, the car can be taken to the next station by uncoupling it from the cars behind it. Remove the disabled truck from the track; then take the caboose jacks and raise the body of the car enough to slip a tie under it across the track rails; let the car down upon the tie, and by running carefully the car can be hauled to the station or side track, sliding on the tie.

If sliding the disabled car on a tie is not practicable it is often a good plan to block up both ends of the car on ties and move the forward truck under the other end of the car and haul it to the station with one end resting on the coupling; or substitute another truck for the damaged one, that being the most convenient way in some cases.

Loaded wrecked cars. It is always best, when a wrecked car is loaded, to remove the load, or transfer it to another car on the good track. Outfits starting to

go to a wreck should provide themselves with all tools and appliances necessary for this purpose.

Broken center pins. Car-truck center pins, which have been twisted or broken in a wreck, may be removed by going inside the car and cutting away with a hammer and cold chisel the iron ring which forms the head and shoulder of the pin. The pin may then be driven down through the bottom of the car.

There should always be a man on hand at a wreck to look after such jobs and promptly remove all broken brake-beams, hanging irons, etc., in order not to delay the work after the cars are picked up, or are ready to be put upon the track.

Pulling on a chain or rope. When pulling on a chain or rope with a locomotive at a wreck, care should be taken not to have too much slack, as chains break easily when jerked. The same is true of switch ropes, but when they are new or not much worn, they will stand a greater slack strain than a chain will. Wire cables are preferable to either a chain or a rope for pulling and they will stand a much greater slack strain if not allowed to become twisted out of shape.

There is always danger of chains or switch ropes breaking when engines are pulling on them at a wreck, and those working near should not be allowed to stand too close to them.

A "dead man" is a device sometimes used to anchor a guy or stay rope, where wrecking cars, engines or derricks have to do very heavy hoisting or pulling. It is made by digging a trench five or six feet deep, at a proper distance from the track and parallel to it. A narrow cross trench is then dug, slanting upward from the bottom and middle of the first trench to the surface of the ground. A good track tie or heavy timber is then buried in the first trench and the rope is passed down through the cross trench and secured to the timber.

Wrecked engines. The first thing to do with a wrecked engine, if the frame is good, is to take jacks and put the engine in an upright position, such as it would occupy if standing on the main track. It may then be blocked up and raised sufficiently to place under it rails and ties, forming a temporary track. The main track should then be cut at a rail joint, and lined out in an easy curve until the ends of the rails are in line with the temporary track. The tracks should then be connected and the engine pulled upon the main track. If the engine stands at such an angle as to require a very sharp curve in the track over which it is pulled, put plenty of oil on the track rails, and elevate the outside rail of the curve.

How to work at a wreck. The first thing to do at any wreck of importance, where cars block the main track, is to use the first locomotive which can be put into service, and with switch ropes pull clear of the tracks all cars, trucks, or other wreckage which cannot be readily put back on the track with the facilities at hand. Proper care should be taken, in doing this part of the work, not to injure freight in the cars. When necessary, remove it from the wrecked cars to a place of safety, and pull the cars and trucks into a position alongside the track, where it will be handy for the wrecking car to pick them up after it arrives.

The moment the track is clear of wreckage, the track force should go to work and repair it, and quickly put it in good condition for trains.

Track foremen should not allow their men to become confused or mixed up with other gangs of men who are present at a wreck, except when it is necessary for more than one gang of men to work together; even then the foreman should keep his own men as much together as possible, in order always to be able

to control their actions and work them to the best advantage.

No matter what part of the work at a wreck a foreman is called upon to do, he should act promptly, and work with a will to get the wreck cleared up and the track ready for the passage of trains with as little delay as possible.

XXII

GENERAL INSTRUCTIONS

Discharges. Upon the day on which a man is discharged the foreman should make out his time in full on the time book, and write opposite his name on the time book, "discharged," or the letters C. G., which means "certificate of time given."

The foreman should always fill out a discharge check, using the regular blank form for that purpose. The man's name should be written in full on the discharge check and spelled in the same way as on the time book. His occupation, number of days worked, and amount due him should also correspond with the same on the time book. The discharge check should be signed by the foreman and forwarded to the proper officer for approval. A board bill should also accompany the discharge check whenever there is any deduction to be made from a man's wages for that purpose.

Foremen should not discharge any of their men without sufficient cause, except when they have received an order to reduce their forces; nor should a foreman keep any more men than the regular force allowed him without orders from his superior officer.

Ride over your section on the engine. Section foremen should take an occasional ride over their sections either on the engine or on the back platform of the rear coach or caboose of a train; and while riding over the track they should not make a pleasure trip of it merely, but should watch closely how the cars ride,

note all the worst places in their sections and what causes these places to affect the smooth running of the train. A train running at the speed of 45 miles per hour does not ride as smoothly as one traveling 20 miles per hour on the same track, because the cars which travel slowly have more time to get righted after the wheels meet with a place out of line, level, gage or surface, while the fast train may meet and pass several of these slight obstructions within a second of time, thus having no time to regain its balance. When a train runs along smoothly for a distance and suddenly swings to one side, if it be on a straight track, the place is either low on that side, or is badly out of line or gage. If the train be on a curve, and the car swing heavily toward the higher rail, there is not enough elevation in the curve at that point. If the car swing toward the inside rail of the curve, there is too much elevation of the outer rail at that place for the speed being traveled. A low joint on the inside rail will cause the train to swing to that side, and the striking of the wheel flange against joints that are hooked in out of line on the outer rail will also throw the car toward the inner rail. A foreman can soon become expert in distinguishing the slight difference in the motion of the car as it swings to either side of the track, and tell the cause by examining the bad places in the track soon after riding over it on the train.

Accidents. All personal injuries to men working in track service should be reported on the proper blank form by the foreman to his superior, and all accidents resulting in damage to the railroad company's property should also be promptly reported. When there are no suitable blank forms a written report should be made, and signed by witnesses.

Go over the track. Section foremen should always, in very stormy weather, go over their sections and ex-

amine all culverts, bridges and other places liable to wash, and report condition of track to roadmaster. In going over section, they should be very thorough in their examination of everything in their charge. See that the telegraph lines are in good order; if they are not, repair them when you can, and report any defects that may need the service of the telegraph line repairer.

Foremen should also notice the condition of all snow or right of way fences, and repair all breaks in them as soon as found. Gates left open by farmers should be closed and secured. Unreliable men, or those ignorant of their duties, should never be detailed to patrol the track.

Raise up wires. When telegraph wires are found down after a storm, foremen should hang them high enough on the poles to insure their working properly and to prevent cattle or teams crossing the track from running against them.

Extremes of temperature. Whenever the temperature changes suddenly there is always danger, whether the changes be due to extreme heat or extreme cold. Section foremen should be very particular to go over and examine all the track on their sections to discover places where track has been kinked and thrown out of line by the heat, or splices broken and rails pulled apart by the extreme cold. Foremen should remember that accidents of the kind mentioned are liable to happen at any point on the road, even where the rails seem to have the proper allowance for expansion, because the change of temperature may come on quickly. Places where the ballast is light, or where the track is not filled in between the ties, are the most likely to be affected.

Surface bent rails. In wet cuts, or other low places, the track often becomes very rough, and the ties sink into the mud in places. The rails then, if of light

weight, become more or less surface bent before the track can be raised up, or repaired properly. If the surface bent rails cannot be replaced by good ones before the track is ballasted up they are apt to cause the foreman much trouble in trying to make them remain in true surface, if he does not understand how to straighten them. This can best be done by the following method: If, for instance, the rail bows up at the quarter or the center, make the ties solid at each end of the bent place on some warm day, then remove enough material from under the ties, where the rail is bent, so that the weight of an engine passing slowly over the rail will bend the bowed place, just as much below level, as it is then above. After a train has passed you will generally find that the rail has resumed its proper shape. If the bend in the rail is downward, hang the center of the bent place upon one or more solid ties, according to the length of the bend, and allow the balance of the track under the rail to remain as it was. Joints which have been allowed to remain low for some time often cause the rail to be come surface bent in the short quarter, and they are very difficult to keep up ever after unless the kink is taken out of the rail.

A loose joint tie in gravel or sand ballast will soon pump out enough gravel to cause the rail to bend a short distance from the end, unless it is taken care of at once. When the foreman wishes to straighten any surface bent rails, he should always signal the first train, and have it run slowly, because there is danger of the rails breaking where they are not fully supported. Surface bent rails which are so bad that they cannot be straightened while in the track may be taken out and fixed with the curving hook and lever.

Low joints. When picking up low joints in gravel or stone ballasted track, particularly where the depressions are only slight, if sufficient force is al-

lowed track foremen should always use tamping bars, or tamping picks, according to the nature of the ballast, to tamp up the track ties to the proper surface level.

Many things other than a weak foundation make low joints in track. Loose bolts in the joint fastenings make low joints because they allow them to bend down under the weight of the engine and cars. Bad gage and line make low joints because the cars, when trains run fast, are thrown heavily from one side of the track to the opposite, and the joint, being the weakest point, is affected most. Wide spaces between the ends of the track rail also make low joints, and assist the car wheels to batter the ends of the rails.

When rails are laid on soft wood ties, or when the ties have commenced to decay, you will generally find that a low joint is wide in the gage between the rails.

The conviction gains ground daily that low joints are due in a great measure to the faulty construction of the ordinary angle bar joints, and this theory is borne out by the fact that roads using improved joint fastenings have very little trouble from this cause.

Examining track. When the track rails on a section become badly worn and need to be repaired often, or when the ground is frozen solid in winter, section foremen should go over their sections daily and examine the track thoroughly for broken or cracked rails, removing such rails and replacing them with good ones.

It is the duty of foremen never to deviate from this rule unless a regular track walker is employed for this purpose, or when they have orders to the contrary.

The section foreman is responsible for the condition of the track in his charge, and he should do everything in his power to contribute to the safety of passengers and trains passing over it. Report all

broken rails to the roadmaster as soon as found, giving brand, weight, age, etc.

Scarcity of repair rails. When repair rails are scarce, and a foreman cannot procure enough to exchange for all the damaged rails in his main track, he can with only a couple of extra rails keep his track perfectly safe by commencing in time to bring into station the worst rails on the main track.

Take the two extra rails out on the section, if good and of the proper length, substitute them for two battered rails, bring the two battered rails into the station and put them in track in the yard or somewhere near the station, in place of two more good rails. Take these out on section as before, and substitute for battered rails. In this way a foreman may exchange four or five carloads of rails, or about one mile of steel, until he receives a supply of repair rails.

Battered rails are safer within one-half mile of a station at the track foreman's headquarters, than out on his section, because trains run more slowly there. Battered rails are less likely to break near the station. They are also much more easily watched, and taken care of. When repair rails are received the battered rails can all be removed at once. In order to be on the safe side, the foreman should place his order for repair rails in time to have them on hand when needed and thus avoid makeshifts.

Changing battered rails. The best method for changing rails which have become unfit for use in the main track, when the rails furnished for repair are of a different length from those in the main track, is as follows:

Put in track near the station a string of repair rails, and take out rails of a proper length to change the battered ones out on the section. In order to do this right and save unnecessary expense and labor always try to have the number of repair rails you

put in track replace a greater or less number of rails of a different length without any cutting. If you have not the right number of rails without cutting one, use a number of rails that will give the least waste.

EXAMPLE:

10 33-foot rails equal 330 feet.
11 30-foot rails equal 330 feet.

OR:

7 30-foot rails equal 210 feet.
8 26-foot rails equal 208 feet.

As will be seen in the above example, there are only two feet to be cut from the last 30-foot rail of the 7 to replace 8 26-foot rails, and for this waste a foreman should select (if he has it) a rail battered on the end, that will give the required 28 feet of good rail.

Extra work. It is customary on most railroads to call upon the trackmen to do extra work occasionally, such as assisting the telegraph line repairer, the bridge carpenters, pump repairers, ets., whenever these gangs cannot well perform their work alone, or when a sufficient force of men cannot be procured.

Track foremen should not assist with their men at any kind of extra work without orders from above. When such orders are received the track foreman should give only the amount of help required, using all of his men or only part, as may be necessary. Never employ all of your force when fewer men could do the work as well, unless your orders require it. Charge accurately on the time sheet, and to the department to which it belongs, all extra work performed by your men during the month. Whenever you do any extra work, for which there is no printed

heading on the distribution sheet, state in writing in the column where you put the time, what the labor was for.

Train accidents. In case of accident to a train, the section foreman who is called should take his men and tools and go to the place, no matter whether it is on his section or not, giving all the assistance possible. Section foremen should not wait for orders to do any extra work which they know to be absolutely necessary, but should do the work at once, and remain out with their men until everything is safe. If a foreman is notified by trainmen or others of something wrong on a section adjoining his own, such as a broken rail, a fire along the right of way, or the telegraph wires broken or down, he should make all possible speed to get to the place of danger without questioning his right to go, because it may not be possible to notify the proper authority and any delay may cause the company considerable loss.

At wrecks. Whenever there is a wreck on the road, the foreman on whose section the accident happens should keep an accurate account of the labor and material expended in repairing the damage done to the track. This account, together with the one of the damage done to rails, ties, spikes, bolts, or to the roadbed, should be put in the form of a report, and properly sent in immediately after the track is repaired. Time of men working at a wreck should be charged to that account on the time sheet.

Water stations. At all the water stations the section foreman should note the amount of water in tanks when passing, and where wind engines do the pumping they should be oiled often, and any defects in them or the pumps should be repaired, if possible, or reported by telegraph. Section foremen and their men should pump water into the tanks whenever the wind engine fails to supply enough for trains.

When it is necessary to pump by hand, foremen should commence to pump before there is any danger of the supply in the tank being exhausted. Where steam pumps are to furnish the water for trains, section foremen should assist the man in charge to do any necessary repairing which he cannot do alone.

Trespassers. Foremen should see that no person is allowed to erect dwellings, stables or other buildings within the limits of the railroad company's right of way, or in any other manner trespass on the company's property, without permission from their superiors.

Protect fences. When burning grass, weeds or other material along the right of way, foremen should be very careful to protect the fence from fire. Never go away from a place where you have been burning rubbish leaving any fire behind you, no matter how small the fire, or how harmless it may appear. It is always dangerous until extinguished. If part of a fence should accidentally be burned, or destroyed from any cause, the damage should be reported at once, giving a correct list of the property destroyed and location of same, so that material to repair the damage can be sent there promptly.

Rails of different heights. All rails of different heights, where they meet at a joint, should be connected with a step splice if a proper form of step joint is not used, and an iron shim should be put under the base of the low rail to give an equal bearing with the high rail. The iron shim should have slots punched in its sides so that spikes can be driven to keep it secured in place. Instead of the splice it is better to use a proper form of improved compromise joint.

Switch stands. All switch stand targets should show green, when locked on the main track, also on

all tracks running parallel to the main track, when connected at both ends. The switch target should show the red signal for an open switch when thrown for a spur track, and the switch should be thrown back to position on the through track, and kept locked, except when the spur track is in use.

Absence from duty. Track foremen should never be absent from duty, unless by permission, except in case of sickness or from some other unavoidable cause, in which case the roadmaster or superior should be notified immediately.

Emergency rails. It is good policy to have repair rails placed at convenient distances, one or two miles apart, along the section where they can be easily reached. These rails can be used in case of emergency to replace a broken rail in the track, and the splices will also be handy to replace broken ones, without the necessity of going perhaps several miles through snow-drifts back to the station for the material wanted. To prevent the rails or splices from being covered with snow, they should be secured on posts set with their tops two or three feet above the surface of the ground.

The condition of the rails as to wear should decide the number of emergency rails to be distributed along the track. Where the rails in the track are badly worn and broken rails are common the number of emergency rails should be greater than where the track is newly laid and the rails not much worn.

Working new men. If it is necessary to work new men on your section, who have never worked on track before, do not lose your patience if they are a little awkward in doing the work. If you can do so, pair these men with older hands. Take a little trouble to show them how you want the work done, in a manner that will give them confidence, and in most cases you will accomplish more good than by using the blow-and-bluster method so common with some fore-

men. Remember that you needed instructions once yourself.

Get acquainted with your section. Every section foreman, as soon as he has been appointed to take charge of a section, should make himself thoroughly acquainted with every part of the piece of road in his charge. Get the numbers of all the bridges and culverts on your section, and their distances from the station north, south, east or west. Get the brand of iron or steel, and if it is of different makes get the amount of each, and find when it was laid, also the length and kind of rails in your side tracks, number of panels of snow fence on your section, height of bridges from the ground, number of public crossings, signs, etc. Keep this account where it will be handy to refer to at any time, and keep it corrected from time to time. By doing this you will be able to answer any questions asked by officials of the road about any part of your section, and in case of a wreck or washout you will be able to locate the place at a moment's notice, and give a close estimate of the kind and amount of material necessary for repairs, in case of damage to track. Keep the information in your pocket. Your head won't hold it all.

Making reports. Find out the correct way of keeping your time and filling out any other reports that you have to send in and make them out as directed. You may have a printed form of some kind to fill out. Answer what is asked in the headings.

Extra men. When you are about to have an extra force of men, larger than you have been accustomed to working, take a little time to plan how you will distribute the men to accomplish the most good. Organization is the main factor in handling the work.

Clear water passages. No vegetable matter, grass, etc., should ever be allowed to accumulate under bridges or near the mouths of culverts, or any other

material that would be likely to catch fire easily, or stop the passage of water.

Neat stations. Section foremen should keep the station grounds clean and neat, and all track material should be piled up in several lots. There should be no disorder; there should be a place for everything, and everything in its place. All of the station grounds not occupied by tracks or covered with ballast, should be allowed to grow up in tame grasses. Such plots should be kept nicely trimmed around the sides and ends, with a view to having them of a regular form, and they should be lined parallel with adjoining tracks. No rubbish of any kind should ever be allowed to accumulate upon tracks, or on the ground close to buildings. It should be taken away and dumped into places that need filling. Section foremen should not spend too much time working around the station, but do what is required there when other track work is not pressing, or when the weather or extra jobs interfere and take up so much of the day that it would not pay to go out on the section.

Look over the yard. Yard foremen should have a reliable man as trackwalker to examine all important switches daily. If his time will permit he should also look after and attend to keys in switch rods, to frog and guard rail bolts, and if the yards be small he may also remove cinders from the tracks and attend to switch lamps; but it is a mistake to put too much work on the trackwalker, as it has a tendency to make him hurry over the yard and not give it a careful inspection.

Bent splices. When a foreman receives old steel rails for repairs he should always examine the splices, especially angle bar splices, and if they are bent in the center he should not use them again without straightening them.

Lining disconnected track. Foremen when lining

track that has been washed out, or that has been disconnected at one end should never commence lining from the disconnected end. Always commence to line track from the end that is connected, and nearest to line, and work towards the end that is disconnected, and when you have moved it once, begin to line as before.

Some foremen with large gangs of men spend several hours of valuable time at a washout, in a fruitless attempt to bring into line the tail end of a piece of track, and when the men can not throw it, cut it into rail lengths and carry into place. This may be avoided if track has been lined in the way stated above.

Ordering tools or material. Track foremen, when ordering tools or material for use on the track in their charge, should not make requisition for more than the amount necessary of either kind. A surplus of tools or track material on hand, which there is no prospect of putting in service soon, represents their value in cash lying idle or going to waste.

Keep men's time correctly. It is a notable fact that the best track foremen keep the time of their men and other accounts correctly, and do everything, as the saying goes, "in ship shape," while the reverse can only be said of foremen who are careless or slovenly. The want of an education is only an excuse, and a foreman, by devoting a little of his time evenings to study, can soon write a good hand, and learn enough of figures to do all that is required of him while in the position of track foreman.

Duplicate time books. All track foremen should carry with them a duplicate time book, and note on the same day any loss of time, or time earned by any of the men working under them. Keep a journal of the work performed by them each day, always charging the proper number of days' labor done by each

of them at each separate kind of work. This record of time and work performed should be transferred at the end of each day to the regular time book and journal of work, which is sent to headquarters at the end of each month.

By following above instructions, a foreman will avoid making any mistakes, and will also be able to refer back to the time of his men, the kind of work done, and date of same, whenever called upon for information by his superior officers.

Track material account. When foremen receive track material of any kind, and it is loaded on cars or unloaded from cars by them, they should check over everything carefully and count the pieces, number of rails, ties, etc.; also note the brand or quality of the same, and take the number of the car. Keep this with your other accounts, no matter whether you have orders to do so or not, as you may be asked to give information on the subject later on.

Printed forms. Track foremen should read and thoroughly understand the printed instructions on all blank forms which the railroad company requires them to use, when making their reports. Many foremen are too careless in this matter, often omitting to put down the answers to printed questions which it is almost impossible for them to miss seeing when filling out the form. Occasionally a foreman will put on his work journal the number of ties received during the month, and at the same time fail to give the number of ties used during the month, or the number on hand, while the latter questions are there on the journal, as well as the question, "How many ties received?" Then the roadmaster must write him a letter a second time and tell him what he should do and wait for an answer. It is just likely that the foreman spoken of above will be changing a rail in a side track, or doing some other kind of work, which could

be put off or delayed without danger for a week or two, when at that time he should have been examining his track after a heavy storm.

He has carried a time card in his pocket for months perhaps, and never informed himself that there was a rule on that time card which required himself and men to be out and examine the track on his section in stormy weather. Foremen of the kind mentioned do not hold a position long under any roadmaster, because they are not reliable; they need to be watched too closely and instructed too often in their duties.

Section foremen's reports. There is hardly a single railway company now in this country which does not furnish its foremen printed blanks for whatever reports they may be called upon to make. These blanks are generally made as simple as consistent with the nature of the report, and the foreman should study carefully the headings and printed instructions which will enable him to fill them out properly. It is most important that such statements are made at the proper time, that all entries are strictly correct and that they are made as concise as possible and in a legible manner. When such reports are completed they should be mailed to the proper officer. In regard to monthly statements of tools and materials received and used, foremen will find it greatly to their interest if they retain a copy of whatever they reported on hand the last of the month, so as to be able to fill the report for the succeeding month correctly. In fact, it is advisable that each foreman keep a little book wherein he can note down all items of interest occurring on his section pertaining to the operation of the road. Such memoranda have often proven to be of great value to railway companies; besides that, it enables foremen to make out duplicate reports in case the original has been lost or destroyed. Better still, keep a carbon copy of all reports sent in.

Shipping track tools. Track foremen, when shipping tools or sending them to the repair shop, should always be particular to secure them in a neat package, so that it would not be possible for any of them to become separated or lost while in transit. The name and address of the person to whom sent should be written plainly on the face of the shipping tag; on the back of the same tag the foreman should write his own name and address, together with a request that the tools be returned to him when repaired.

A very convenient arrangement for securing tools together when shipping them, may be made by running a piece of chain through the tools or around them, and locking with a spring key after passing one of the end links through one of the other links of the chain. The key should be flat and just wide enough to fit the links in the manner mentioned. Soft wire is superior to twine for securing tools or for tagging them.

Distance to set out danger signals. Danger signals should be set out a distance of not less than three quarters of a mile in both directions from the point where the track is impassable for trains. This distance can be measured by counting one hundred and twenty thirty-three-foot rail lengths, in the direction you are going to set out the signals; or when the telegraph poles are one hundred and fifty feet apart, the signals may be set out twenty-six telegraph poles distant each way from the point of danger.

When flagging at obscure places, or in the vicinity of descending grades, where it is difficult to stop a train, the distance to set signals must be increased and the telegraph operator at the next station should be informed, so that trains can be held until track is cleared and safe for their passage. The flagmen should remain out with the signals until the track is

repaired. When the track has been repaired, and made safe for trains, the flags, torpedoes, or other signals should be removed immediately. *Of course all flagging should be done under the rules prescribed by the railroad company by which employed. This remark also applies to all other work also.*

Always keep signals with you. A track foreman should always keep on his hand car, ready for instant use, a full supply of torpedoes, red flags, or red lanterns, so that if any accident should render the track unsafe for the passage of trains, he would be prepared to protect them promptly. Flagmen sent out to patrol the track should not be allowed to proceed without having all the necessary signals to stop trains. The foreman should instruct them thoroughly in their duties, as he is responsible for them.

The first duty of a track foreman when he finds a dangerous place in the track, no matter whether it is on his section or not, is to set out stop signals at once; he should then go in the direction from which the next train is expected and report the trouble at the nearest telegraph office.

Time cards and rules. A track foreman should keep well posted on the time of all regular trains passing over his section. Read over all the rules on the time card every time a new card is issued on your road.

Look out for signals. Foremen should always look for signals on all passing trains. Another section of the same train which has passed, or a special, may be following close behind. The track foreman and his men should be fully informed, and keep well posted as to the meaning of all signals displayed on passing trains.

Replace signals. Trackmen finding danger signals along the track should leave them in the same position as found, and if the signals are injured so as to be

unsafe, they should be replaced by good signals of the same kind, or a man should be left to guard the point. It is the duty of a track foreman, if he find danger signals, to go forward and ascertain their cause, and to give assistance with his men, if the trainmen require their services.

Injured signals. All sign signals placed along the track for the guidance of trackmen or others (when injured or broken), should be repaired at once, and placed in position by the trackmen; and if they are destroyed or rendered useless, the foreman should at once make requisition for new ones.

Comply with the rules. Section foremen or others should use all signals strictly in compliance with the rules of the road governing their use. Never set out a danger signal at a shorter distance than that which is specified in the rules of the road as correct, because a serious accident may be the result, if a train cannot be stopped in time.

Location of whistling posts and signs. Whistling posts for highway crossings should be set one-fourth of a mile from the crossing, on the engineman's side of the track. Whistling posts or signs of any description should never be placed in a cut if it is possible to avoid it. It is always better to increase or diminish the distance to get them out of the cut. The distance should always be increased where there is a down grade, or when the law requires certain signs to be placed a specified number of feet or rods. This rule should also apply on sharp curves.

Posts and signs should be set firmly in the ground, and ordinarily so far from the track that if knocked down or blown over, they will not fall upon it. Never set any signs in a leaning or twisted position. Highway crossing signs should be set far enough away from the center of the wagon road, so that wagons loaded with bulky material, such as hay or straw,

cannot strike the sign post or the cross arm at the top of it.

Disregard of danger signals. Section foremen should report promptly any failure on the part of trainmen to honor danger signals set out by himself or his men. If an engineer run at high speed past the point for which you have set out a slow flag, or if a train run past a dangerous place before stopping, for which you have set out the necessary stop signals, you must report all the facts without delay, giving the engine and train number, and the time they passed the place where you were working. Foremen should not overlook any neglect of duty by the trainmen in this matter. Always remember that the safety of trains and the lives of passengers and employes depend in a great measure upon a strict compliance with the company's rules.

Look out for trains. Section foremen should always keep a sharp lookout for trains while working on track, while using hand cars, or while transferring material from one track to another on cars. Never trust too much in this matter to the men, as they are not held responsible for accidents. To be on the safe side, a foreman should always be expecting a train; he will then be prepared for all extra trains or specials, of which he has no previous notice.

Always be prepared. Whenever it is necessary for a foreman to go to a wreck or washout, or to assist at any kind of work which calls him away from his own regular work, he should be prepared, having lanterns ready to light, tools all on the car, tape line in his pocket, etc. Don't start out half equipped with tools. When you find a place to fix up or repair, and there is need of tools which you have not with you, you will have to send after them, perhaps delaying trains for an hour or more because of your carelessness. Don't go out on the track and discover a broken

rail, and at the same time find that everything necessary for repairing it is on hand except chisels, and they are at your tool house, seven or eight miles away. A foreman who is careless in these matters is generally so in everything else he does, although he may hold his position for a time. The roadmaster or supervisor has him marked down as poor material, and will always remove him as soon as he can put a better man in his place.

Hand car and tool houses. The hand car and tool houses should be kept outside the switches at yards, or wherever is the most convenient place. They should be located so that the men can get to and from work without being delayed by trains standing on the tracks. Tool and hand car houses and track supplies of any kind should always be placed at a sufficient distance from the track not to obstruct the view of the trainmen or be likely in case of accident to fall on or near the track.

Telegraph office report. When a section foreman's headquarters are located at a station, he should report at the telegraph office for orders and inquire for messages before going out to work every morning and immediately after working hours in the evening.

Removing hand cars from crossings. No material of any kind should ever be piled or placed on a highway where it crosses the track. Section foremen or others should never take off their hand or push cars and leave them on the highway or private wagon crossings unless it is absolutely necessary to do so to get out of the way of a passing train. The car should then be immediately put back on the track and removed to a proper distance from the highway. Section foremen should provide places along their sections, at convenient distances not less than 100 feet from highways or crossings, where they can take off

their hand or push cars, and leave them when necessary. Obstructing highways by leaving thereon track material, hand cars, etc., has been the cause of numerous accidents and claims for damages against railroad companies.

Throwing switches. Track foremen should not be in the habit of throwing switches for trivial reasons. Although it is the custom on most railroads to allow section foremen to carry a switch key, they should not abuse this right by unlocking and throwing switches to move a hand or push car without a load from one track to another, or to accommodate trainmen who should do this work themselves. Hand cars and push cars, with a light load, can as well be moved from one track to another, where the rails come close together, without throwing the switch. Men employed on the section should not be trusted to throw a switch, except in the presence of the foreman. When a switch has been thrown on a side track, the person throwing it should not leave it until after throwing the switch back again for the main track and locking it.

Any foreman who would throw, or allow others to throw a switch from the main track, and leave it in that position while performing a piece of work, or until it suited his convenience to throw it back, should be discharged; and he would be criminally liable if any accident should happen through his carelessness. Those intrusted with the operation of switches cannot be too careful.

Leaving hand cars on track. Some track foremen have a habit of leaving hand or push cars on the track, while cutting weeds or doing other work which requires frequent moving from place to place. This should not be done. The main track should be kept clear at all times, except when trackmen must occupy it to do necessary repairs; at such times or when mov-

ing loads of material on cars, foremen should protect themselves with proper danger signals.

Foremen should not leave hand cars on side tracks as they are likely to be smashed by trains switching, and cause a wreck at the same time.

Loaning tools, cars, etc. Track foremen should never loan to persons outside of the company's service any tools, hand car, velocipede car, push car, or track material of any kind which is intrusted to their care, without permission of their superior officers. Foremen themselves or their men should not use hand cars, velocipede cars, etc., on the track outside of regular working hours, unless in the company's service, or with permission.

Foremen who adhere strictly to this rule are very seldom requested by outside parties to grant them any privileges, and thereby save themselves annoyance. Track foremen should remember that company material of any kind, no matter how valueless it may appear to them, is still the company's property; and that they have no right to appropriate it for their own use, or to sell it to others, without authority from their superior officers.

Different varieties of ties. On a railroad where different varieties of ties are used in the track, the softer kind of wood should be used in straight track, and the hard wood ties should be used in the curves, and in sags between heavy grades where the speed of trains is very fast. If hard wood ties can be procured for curve track they should not be mixed with soft wood ties in the same track, because the rails will in the course of time cut a bed in the soft wood ties, and thereby affect the surface of the track. The ends of bridges and under switches are also good places to use hard wood ties, where they can be furnished for that purpose. White cedar is the best soft wood tie; white oak the best hard wood tie.

The place for tools. Foremen should bring home every night and put in the tool house all tools which they have been using on the track during the day. Never leave tools out on the section. Unscrupulous persons who live near the track or who may pass along the track are very apt to appropriate any tools which they find. Any loss of track tools should be reported by foremen.

Cutting rails. Whenever it is necessary to cut steel rails, track foremen should instruct the men how to do it properly. All steel rails should be cut as accurately as possible as to length, and allowance for expansion should be deducted from the length of the rail. No careless work should ever be allowed, such as cutting the rail short of the proper length.

The line of the chisel cut around the rail should be continuous and square across the rail. Iron rails, as a general rule, need to be cut deeper than steel before they will break off. Hard steel, if cut deep, is likely to break off on either side of the cut, leaving a bad, unshapely end on the rail. To break off a rail at the cut, lift up the rail at the end nearest to the cut, and let the cut place fall over a piece of rail or angle bars laid on a tie, or something solid. Short pieces to be cut from rails may be broken off with the sledge. When cutting rails trackmen should not use a spike maul to strike the chisel, because this destroys the face of the spike maul, and splits pieces from the heads of steel tools, making them worthless in a short time. A good sledge for striking hard steel tools should be one of the tools on every section, and should be taken in preference to any other tool of the kind whenever necessity requires its use.

Ballast in yards. The yard track at all stations inside the switches should be dressed off level with the tops of the ties, both inside and outside of the track rails. When there is enough ballast the shoulder

should be level and of sufficient width to allow trainmen or passengers room to walk along outside the ties. Where yard tracks are close together no rub-

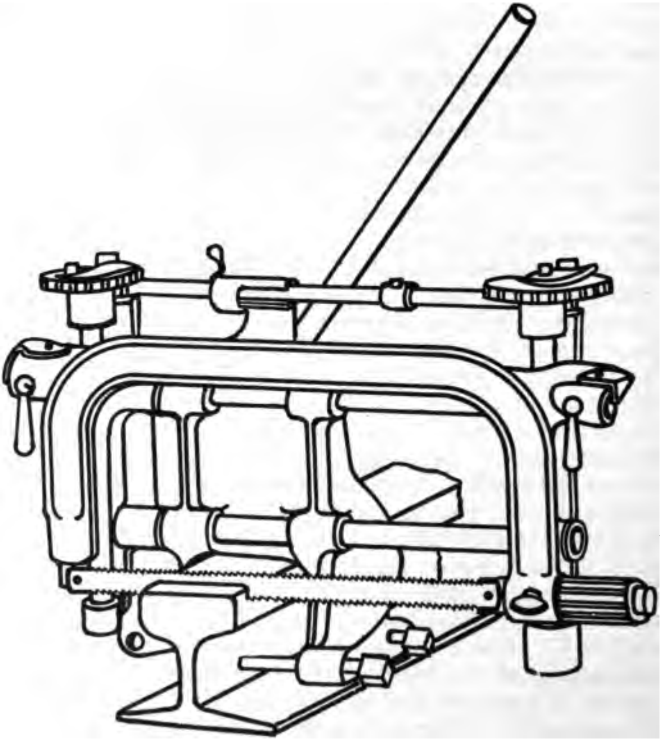


Fig. 82. Portable Rail Saw

bish or obstructions of any kind should be placed on the space between them or allowed to remain there.

Execute orders promptly. When the foreman receives an order to do any special piece of work, he

should do it at once and finish it up in the manner in which he is instructed. It is of the greatest importance that track foremen adhere strictly to this rule. Never let work wait to suit your convenience, nor do any work in a way contrary to that in which you are ordered to do it.

Protection against fires. In the fall of the year when the weeds and grass along the right of way have become dead and dry, section foremen should take every precaution to protect the company's property, and that of persons living near the track, from damage by fire. Fire started by sparks from locomotives, or from other unknown sources should be looked after at once and extinguished. Do not cease your efforts until you are sure all danger is past. All wooden structures, bridges, culverts, etc., should be examined as often as you pass them and any combustible matter which may be close to the timbers should be removed. Be particular, when burning rubbish or grass along the right of way, always to work with a favorable wind. Run no risks, and if you see a doubtful smoke along the track, take your men, go to it at once, and find out what has caused it.

Report stock killed. All stock killed or injured, and found lying on the right of way by the foreman, should be reported promptly to headquarters. Section foremen should always report the stock killed or injured. It is the duty of foremen to make an examination of the body of the animal found, find the owner if possible, and get the age and cash value of the animal. If it was struck by a train, give engine number, train number and time of the accident, if you know it. In your report give all other information which is likely to be of any value to the company you are working for. If the owner of a dead animal does not remove it from the right of way, the section

foreman should take his men and bury the carcass after investigating the cause of accident, etc.

Foremen have no right to appropriate to their own use (or to allow others to do so) the carcass or hide of any animal killed along the track.

Damage by fire. When property along the right of way has been destroyed or damaged by fire, the section foreman should go to such place at once, examine the ground thoroughly, measure the distance from the center of the track to where the fire started, find the value of the property destroyed, make out an itemized estimate in his report; and also state the direction of the wind when the fire was burning, and give a true account of everything as far as he knows. Do not accept the statements of others unless you know them to be correct.

Be careful of material. When a track foreman lays or extends a piece of track, as soon as he has finished the job he should have every loose spike, bolt, splice, etc., picked up and taken care of. Track material lying around where a gang of men has been working is very good evidence that the foreman is careless about his work and wasteful of the company's property.

Never allow old iron taken out of track, old ties, broken brakes, and scrap, etc., to accumulate on your section. They should be taken to the station or placed in regular scrap bins or at platforms where it will be handy to load for shipment later.

Do first what needs to be done. A track foreman should always have his work planned ahead. By giving close attention to the track, as he passes over it daily each way, a foreman will always be able to see what needs to be repaired most, and it is hardly necessary to say here that such work should be done at once. Do not ride over the same low joint every day, a joint one-half inch out of gage or line, or pass

the same broken joint tie or bolt hanging loose in the splices, expecting to fix such places the next week or waiting until the roadmaster calls your attention to these things. The longer you wait the more these little odd jobs increase in number, and at about the time you have set to do them you are called off to some other place. The work still increases during your absence, and in this manner things go on the year round. You are always behind, always worried; you think the roadmaster hard because he urges you to hurry; you make excuses for yourself, as for instance, that you were putting up a nice piece of track somewhere else on the section. Always remember that if you had ten miles of the best track in the country, all good track except one rail length, and that rail dangerous, the balance of your section, no matter how good, would not save a train from getting wrecked, nor you from the blame that would justly fall upon you. In no other line of business does the old saying apply with greater force than on a railroad: "Never put off till to-morrow what should be done to-day."

How to do work. Experience will teach a foreman that the secret of keeping a good track on his section lies in doing all work well. Slight nothing. Do not surface up track to make a big show for the present, but surface it as fast as it can be done to make track that will remain good a long time. Very smooth track, well lined and gaged, will stay good sometimes for years without much repairing. On the other hand, track that might be called good, with an occasional slight dip in the surface, if there is much traffic over it, will soon be bad track because, where quarters or joints are perhaps only one quarter of an inch low after the track is surfaced, the weight of an engine or loaded cars strikes such low places with great force, and gradually increases the depression until

the track becomes very rough and dangerous. If not cared for, low places in track knock out of gage and line besides getting low. The same method of doing work will not answer always. Foremen should adopt a method of doing work that will give the best results with the kind of material furnished.

If there is only dirt for ballast, don't always be telling what good track you could have with gravel or rock, but see how good a track can be made with dirt.

Foremen on duty. When on duty, the foreman should always be with his men and assist them in doing the work. It is his duty also to instruct his men by word and example as to the proper manner of performing all the different kinds of work in which they are together engaged.

Adopt the best method. If you can improve on the old method of doing any kind of work, when you are not satisfied with the results of a trial adopt a new plan. When you do any kind of work on track, and it does not give satisfaction, always try to find the remedy for its defects. Do not say it can't be done, but remember that a man who finds himself in a difficult position, if he has good judgment and a lively brain, can work out some of the most difficult problems without any previous knowledge of them. Never take a slow method to do any kind of work that you can do as well in a quicker way. Don't forget that the world moves, but move with it. Try to learn something from the experience of others who are successful in the same business as yours. A trifle of time gained soon amounts to a day, month or year, if multiplied many times.

Take for instance the case of two foremen putting new ties in the track. One removes all the dirt or ballast from the center of the track to the outside of the rails in order to get a number of ties into

track at once; the other foreman moves the material in the center of track back upon the new ties as fast as he puts in two or three; and by that method the latter foreman saves himself and his men the labor of shoveling many yards of ballast from outside the track rails to fill the center of the track. To bring a section of track up to anything like perfection, the foreman in charge of it must look closely after all the work in its minutest details, and allow nothing to go undone which would contribute towards improving the track. None but careless foremen will line up one side of a track well and then leave it without taking the kinks out of the other side at the same time. A careless foreman will put a new tie into track without taking up to surface a low joint close to it. He will cut weeds past a joint with a bolt broken out of it without putting in a new bolt. He will make a trip over the section, and never notice a break in a fence, or if he does note it, will wait until he is notified by the roadmaster to fix it. It is likely that you will find the same foreman surfacing a piece of track without using a spirit level on it. Such a man is not fit to make a good laborer, much less a foreman; and the piece of road in his charge will soon run down if he be not discharged and replaced by a foreman who has a desire to improve the track whenever he does work on it. The work of a careless foreman puts the roadmaster to watching him, because he informs on himself every day, while the careful, industrious foreman makes a good, permanent job wherever he works, and the result is a first-class track where recently may have been a very rough section.

Work train service. Trackmen who are in charge of work train gangs should make it their business to keep the men employed whenever the train is delayed in the regular work. There is always plenty to do along the track at any point. A good foreman will

have his work laid out ahead so as to avoid delays except those which are unavoidable.

When possible, it is always best to put a good practical workman in charge of a gang of men on a work train. It is poor economy to have an inexperienced trainman in charge of a train and a large crew of men, as is often the case. When the position of foreman over the men and conductor of the work train is held by one person, the preference should be given to a trackman, if competent to run the train, or to a man who has had some experience in both branches of the service.

Source of responsibility. Work train conductors and foremen of gravel pits, or of steam shovel outfits, should receive their working orders from, and be strictly responsible to the roadmaster or supervisor on whatever division of the road they are working at the time. Work train conductors should report daily on blank forms furnished for that purpose; and, if required, they should also report to the division superintendent. They should also make a lay up report to the train dispatcher every evening after quitting for the day, and inform him where the train will work the following day.

Work trains should always lay up over night at a telegraph station.

Conductors of work trains should see that the axle boxes of all the cars in their trains are properly packed, and oiled as often as necessary, and that all defects in rolling stock or track where the train is working, are repaired. All accidents to cars, and anything which would interfere with or delay the work should be reported promptly, so that they may be quickly remedied.

Care of interlocking switches. This branch of railroading is extremely intricate, and requires in the majority of cases a special department to handle it.

Interlocking, as the name implies, is something that is locked together with something else; or, in other words, if the switches controlled by the tower are set for one route, this will be indicated by the signals, and no change can be made until all the signals are back to the danger position, and then the switches can be thrown and the indications given accordingly.

After the plant has been put in place a considerable portion of the working of it falls on the trackmen. All running parts should be carefully cleaned and oiled daily. The bolts at heels of moving points should be so adjusted that an additional strain will not

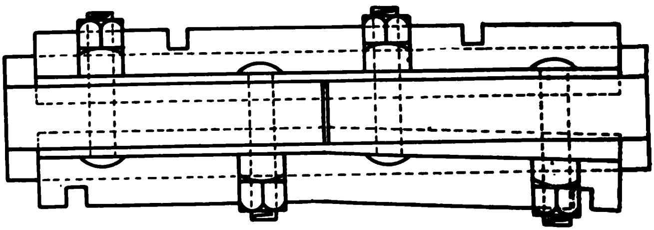


Fig. 83

be brought on the levers in the towers. A very good method of accomplishing this is to use an angle bar, which is slightly bent, at the heels of movable point frogs and switches. This can best be described by reference to the sketch, Fig. 83.

In this the inside of the bar is bent from the middle toward the end of the moving point an amount equal to the throw at the end of the bar; then very long bolts are used with lock nuts. This does away with any hinged device, and is absolutely safe. Also stops should be used at several places on the side of the moving point farthest from the stock rail, so as to do away with any lost motion.

With slip switches it is best to have the joints at the heels of all moving points come on a tie, these acting as solid supports.

All ties should be tamped where interlocking is used, so as to prevent any settling; and no connections should be attached to the ties except where absolutely necessary, as this renders renewals and changes much easier, there being nothing to disconnect or replace.

The adjustment of all point rails should be given careful attention, so as to be sure that they always stand up to the stock rail.

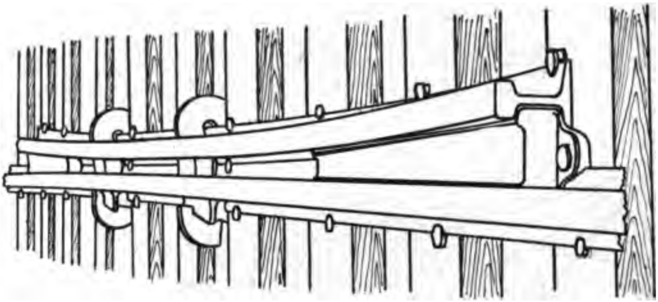


Fig. 84. Foot Guard

When connecting up switches with piping from towers, the person in charge should ascertain that the track is to proper grade and not likely to settle before the foundations for pipe lines are set; then these can be placed to a proper height.

In heavy snow storms trains should be cautioned to pass over switches that are interlocked, with care, as it is often advantageous to disconnect certain parts to keep the plant running. For instance, detector bars, being so long, get filled and thus are rendered hard to move; these can be disconnected. If the locks

and switches, owing to the severity of the storm, are rendered useless from the tower, it is to the foreman's advantage to have these disconnected also, and throw the switches by emergency stands. This is an extreme case and should only be resorted to when a tie-up is imminent; and as trains then have to move on a hand

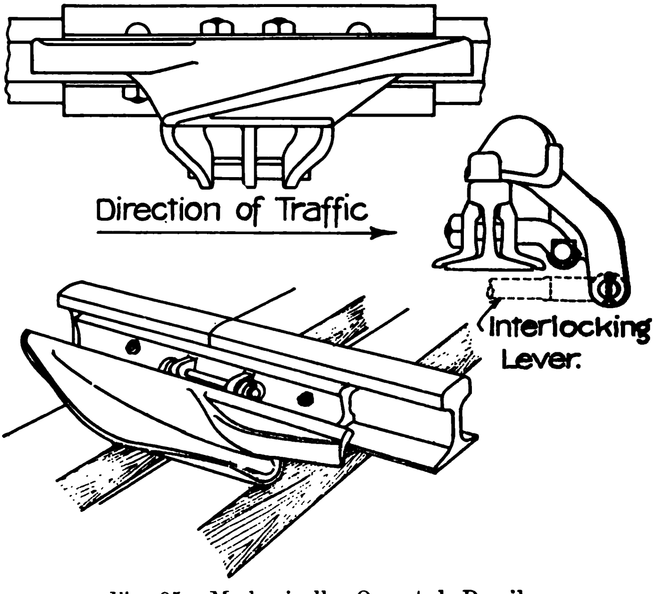


Fig. 85. Mechanically Operated Derailer

signal they should use great precaution. These stands should be made as small and compact as possible and set up on ties ready to be connected in times of emergency.

Track inspection. There should be a well organized system of track inspection in force on every railroad, and it should be made efficient in proportion to

the amount of traffic and the condition of the track.

On roads where only ten trains a day or less pass over track, an arrangement could be made to have the section foreman, on days on which his work does not call him to the end of his section, send a man over to examine the track from wherever the gang is working and whenever there is economy in it the hand car could be run to the end of the section in preference to sending a man over on foot. In case of storms all track should be examined as necessary day or night.

When a railroad is double tracked, or there are a large number of trains daily over a single track, a regular track-walker should be employed to go over the whole section once a day in each direction, and to report to the section foreman, and also to the station agent or operator, when there is a station at both ends of the section.

The track-walker should so time his passage over the section as to be able to see all the track or at least the most dangerous points, a short time ahead of passenger trains.

During extremely cold or stormy weather the track needs to be examined particularly and in order to insure inspection of track at least once a day, it is recommended that, when it is not possible to run a hand car, the section foreman with one of his men be allowed to ride one way on trains, against the storm, to the next station or to the end of his section and return back over the track on foot, carrying what signals and tools would be necessary in case of emergency.

The conditions are so varied on different railroads and sometimes on small divisions of a railroad that each company can best organize a system of track inspection which in the judgment of its officers is best suited to its wants. The foregoing methods are only offered as suggestions from which something more useful may be designed.

XXIII

PRACTICAL HINTS FOR TRACKMEN

Safety first. The first ten of the following hints were published in a safety poster printed by the New York Central Railroad in sixteen languages, and published in the January 22, 1915, issue of the Ry. Age Gaz.

1. Don't take chances. Think what "Safety First" means to you and to your family. Do your work in the safe way and be careful to avoid injury to yourself and others.

2. Always be on the watch for trains in both directions, and when you step from one track to another, ALWAYS LOOK IN BOTH DIRECTIONS FIRST. Do not stand close to rail of track while train is passing.

3. When your foreman signals you to step from track do so AT ONCE. Don't wait. Don't try to remove an extra shovelful of dirt first. That last shovelful of dirt may cost you your life.

4. Never stand or walk upon the tracks except when necessary in the performance of your work, and then watch for trains in both directions, as trains are liable to be run against current of traffic or run in either direction at any time.

5. Never use tools that have battered heads or are otherwise defective or unsafe for use. As soon as you discover a tool that is defective, put it away and call it to the attention of your foreman and get a good one in its place.

6. Always put tools or material of any kind where they cannot be struck by a train. Be particular about cleaning up rubbish you find lying near the track and never leave anything lying about for other men to stumble over.

7. Never overload hand cars either with material or men. In operating hand cars be sure you afford yourselves all the protection that is required by the rules.

8. Never get on and off moving cars or trains. Your duties do not require it, you are not accustomed to it and it is a dangerous practice.

9. Always play safe. Think about what you are doing and don't forget that you are working on a railroad.

10. Obey the rules. They were made for the protection of yourself and others and they should be observed to the letter.

11. In England during the year 1913 one trackman in 611 was killed, and one in 19 injured. In the U. S. about 85 per cent. of the maintenance men who are killed, and 35 per cent. of those who are injured are struck or run over by cargo engines, practically all these accidents being due to carelessness, thoughtlessness or indifference because the men are violating the rules when they fail to clear the tracks on the approach of a train.

12. **What can be gained by looking out for safety.** As a result of attention to safety the number of injuries to maintenance men on the B. & O. for the first half of 1914 was reduced 66 per cent. as compared with the same period of 1913. On the C. & N. W. the reduction during the fiscal year of 1914 as compared with the fiscal year of 1910 was 39$\frac{3}{10}$ per cent. in deaths to track men, 27.7 per cent. in injuries to track men, 33.3 per cent. in deaths to bridge men and 38.8 per cent. in injuries to bridge men; the average decrease in accidents to all employees was 41.1 per cent.

The El Paso & Southwestern Safety Department reduced the number of fatal accidents to track men 37.5 per cent. in 1914 as compared with the previous year. Similar figures on the Wabash show 46 per cent. decrease in fatal injuries.

Classified rules for safety and maintenance. The following rules were suggested by Mr. J. T. Bowser of the Queen & Crescent Route, and published in the Ry. Age Gaz. They are so excellent and well arranged that they are here given in full.

13. *General.* It is the duty of all employees to watch for, and to report to their superior officers, all matters involving the safety of employees and the public.

14. When it can be done without neglect of other duties, employes will warn off trespassers or others whose duties do not require their presence on the right of way or tracks.

15. General instructions concerning safe practices must be posted in tool houses or camp cars where they can be seen by employees, and employes should be required to read such instructions.

16. *Supervision.* Employes entering the service are required to read or have read to them outstanding instructions or rules involving their own safety or that of others.

17. Foremen working on double track will require their men to step off of both tracks while trains are passing.

18. Foremen are required to stay with their gangs at all times, to keep watch for trains and to see that their men perform their work in such a manner that neither their own safety nor that of others is endangered.

19. Yard foremen or others in charge of men working in places where the passage of engines or cars is very frequent, are prohibited from taking part in the

work at hand or performing any other work which will prevent their keeping a proper lookout for trains or cars, unless they assign some responsible man to keep such a lookout.

20. Men having defective sight or hearing or men who are habitually careless in their work are not considered desirable employees and must not be retained in the service.

21. The use of gauntleted gloves by employees handling heavy material is prohibited.

22. Except in cases of emergency, employees must not handle work with which they are not familiar. (This applies particularly to handling of equipment and electrical work.)

23. Under no condition must high tension electric power wires be handled by other employees than those whose duties require them to look after such matters. In cases of the breakage of such wires, a watchman should be left at such break until the arrival of the proper person to make repairs.

24. *Clearance and bad footing.* Except on explicit instructions from proper authority, no track will be laid, nor will any structure be erected, which will not give ample clearance to a man on the side of a car.

25. When conditions necessitate the construction of a structure or track which does not afford proper clearance to a man on the side of a car, the point should be protected by proper flagmen.

26. When it is necessary to obstruct or in any manner change the nature of the ground where trainmen or others habitually walk or alight from trains, the despatcher or other proper authority must be advised so that notice to this effect may be put out.

27. When it is necessary to make any radical change in tracks, structures or appliances in habitual use, proper authorities must be notified so that notice to this effect may be issued.

28. Excavations left over night must be protected by railings, and temporary obstructions of any nature must be protected at night by red lights when this can be done without danger of such lights being confused with signals for train operation.

Hand cars, push cars, motor cars and velocipedes.

29. Track foremen will not permit the use, on their sections, of hand, motor, push, or velocipede cars, by others than those whose duties require the use of such cars or those having written permission from a proper authority.

30. The use of any of the above cars for other purposes than the performance of their proper work is prohibited.

31. Cars will not be used except when in charge of a foreman or a competent assistant.

32. When meeting a train on either one of a double track cars must be set off.

33. Where operators, 'phones or other means of communicating with the despatcher are available, foremen will obtain line-ups on trains before going out with cars.

34. Foremen will protect their cars by flag when passing through tunnels or over portions of the line where trains cannot be seen for a sufficient distance to enable cars to be set off.

35. The use of hand cars with wooden handles is prohibited.

36. Foremen will not carry, or permit to be carried on their cars, any one not an employee of the company or any employee whose duty does not require the use of the car.

37. *Use of locomotives or trains.* Employees in the maintenance of way department are prohibited from riding on locomotives. (This applies to work trains as well as other trains.)

38. Except in the performance of their duties, em-

ployees in the maintenance of way department are prohibited from swinging upon or riding on trains or cars.

39. *Camp cars.* When camp cars are to remain at one station a week or more they must be spurred out or otherwise protected from trains or cars.

40. All movable articles in camp cars must be fastened down or otherwise prevented from moving when cars are to be handled.

41. Heavy tools or material must not be suspended but must be placed on the floor or otherwise prevented from moving.

42. Foremen in charge of cars are required to see that steps, hand holds, ladders, etc., are maintained in safe condition.

43. *Special equipment.* The responsibility for the maintenance of all special equipment in safe condition lies primarily with the operator, but foremen in charge of work on which such equipment is engaged will make frequent inspection.

44. Lines, blocks and other apparatus on derricks, hoisting engines, etc., must be thoroughly inspected and tested before being used after the machine has been out of service.

45. In freezing weather all water must be drawn from a boiler at night unless provision is made to keep it hot, and when equipment is to be stored, water must be drawn from boilers regardless of weather conditions.

46. *Road crossings, gates and fences.* It is the duty of section foremen to see that all grade crossings are maintained in a safe and passable condition, especial care being exercised during the automobile season.

47. Section foremen will keep cleared away from crossings weeds or other obstructions which prevent a clear view of approaching trains.

48. All employees will close gates in right of way

fences when they are found open and will endeavor to have parties who use these gates keep them closed.

49. Foremen will look out for breaks in the right of way fences or other conditions which will permit the entrance of stock onto the right of way and will remedy such conditions or will report them to the proper authority.

50. *Inspection and use of tools.* Foremen will satisfy themselves daily that all tools used by the men under their supervision are in safe condition, and they will prohibit the use of tools found to be defective.

51. The use of jacks on the inside of the rail is prohibited.

52. Tools must be removed from between the rails or from points close to the track while engines or cars are passing.

53. Tools not in use must be kept picked up and placed where they will not be an obstruction.

54. *Scaffolding.* Foremen in charge of work which requires scaffolding will personally inspect all material to be used in the scaffolds and satisfy themselves that such material is entirely safe for use.

55. Foremen will personally oversee the construction of scaffolding and will see that a safe construction is used. During the use of the scaffolds foremen will see that they are not overloaded.

56. The use of scaffolds by employees or others whose duties do not require it, is prohibited.

57. Runways or ladders must not be located under scaffolds or at other points where tools or material are likely to fall, and where a considerable amount of work is to be done temporary railings must be erected to keep men from going beneath them.

58. Cable and tackle scaffolds which have been stored or shipped must be thoroughly tested for deterioration or injury before being used.

59. *Loading and unloading material.* Cars must

not be loaded beyond marked capacity and top-heavy loading must be avoided.

60. Foremen will inspect all material to be used for standards or stakes and will see that they are securely applied. Properly braced end boards must be applied where rails or similar material are loaded on flat cars.

61. Rails will be loaded by machine where possible, but when necessary to load by hand the following precautions must be observed: (A) Divide the gang equally on the ends of the rail; (B) Do not attempt to throw rail unless an ample force is at hand to throw it clear; (C) designate one man to call directions and prohibit others from calling; (D) do not attempt to load where men cannot get away readily should the rail fall back.

62. Loading must be discontinued while trains or cars are passing on adjoining tracks.

63. When unloading material a lookout must be placed to warn persons passing the car.

64. Material should not be unloaded from both sides of a car at once but from each side alternately. The same principle applies to loading material.

65. Men should be called out of the cars when material is being dragged out of hopper bottom cars and should not be permitted to remain in any car while it is being switched.

66. *Handling of explosives.* The use of torpedo signals on station grounds is prohibited.

67. The storage of dynamite or other explosives in tool houses or camp cars is prohibited.

68. All shipments of explosives must be made in accordance with the rulings of the Bureau for the Safe Transportation of Explosives.

69. The use of explosives by others than experienced men is prohibited.

70. Charges which fail to explode must not be approached until the expiration of ten minutes and they

should be removed only by experienced men using no metal which could cause a spark. All others must remain at a safe distance.

71. Explosives must be drawn from the magazine only as required and must not be left on the work under any condition.

Dont's. The following list of 65 hints was published by Mr. J. G. Wishart, of the C. R. I. & P. Ry. in Ry. Eng. & M. of W. in 1913:

72. Don't trust to a red flag unless you can see it. Someone may have stolen it.

73. Don't obstruct track in the face of a passenger train.

74. Don't put your track jack between the rails.

75. Don't shim track with soft wood or temporary material.

76. Don't surface your track down hill if you can avoid it.

77. Don't raise your track more than necessary at summit of grades.

78. Don't take out ties that are serviceable.

79. Don't leave your tools out on the section for tramps and train wreckers.

80. Don't leave spikes or track bolts where they can be placed on rail by children playing in the neighborhood.

81. Don't use a briar scythe where you should use an axe or bushhook.

82. Don't cut grass with a bushhook.

83. Don't use a tamping pick after the head has been practically worn off.

84. Don't burn your ties in the evening and leave the fire when you go home at night.

85. Don't send one man over the track to tighten up joints; he won't do it. Take the whole gang and get it done.

86. Don't leave overhanging rocks in cuts or tunnels that you know should be removed.

87. Don't leave a broken rail because it matches up perfectly. Remove it from main track and before using again saw off broken ends and drill for angle bars; it is preferable to replace it with a full length rail.

88. Don't smooth the track and forget to line it. Bad line will jerk a train worse than low joints.

89. Don't use a bad lever in a hand car. It will break when you want it to hold, and is liable to cause an accident.

90. Don't leave a switch point that does not fit up perfectly.

91. Don't permit a spring rail frog to remain with the point spread open.

92. Don't leave crossing plank projecting above the top of rail.

93. Don't leave broken angle bars in the track.

94. Don't leave your hand car on a crossing where it will frighten horses.

95. Don't leave bolts in the rain, where they will get rusty.

96. Don't leave your tools along the road, where they can be stolen.

97. Don't dig a ditch and then throw the dirt where it will wash back into it when it rains.

98. Don't ballast track where the roadbed is not wide enough to hold it.

99. Don't leave dirt or foul ballast where it will hold water under the ties.

100. Don't try to draw a rail with a spike—hold it to gage with a bar and drive the spikes straight.

101. Don't carry non-employees on your cars.

102. Don't trust to a red flag without torpedoes; you may need the shells to prove you had a flag out.

103. Don't waste dirt in a cut that you know should be put on the adjoining fill.

104. Don't leave ties unspiked.

105. Don't go to work without your level and gage.

106. Don't leave your car and tools around station platforms, where they will obstruct travel.

107. Don't leave your section without permission from your superior except in emergency.

108. Don't allow ballast to roll down the bank or lie in ditches.

109. Don't let new ties roll down the bank when distributing them.

110. Don't throw steel rails off cars in such a manner as to bend them. They should either be skidded off, or dropped flat, where they will not fall on other obstructions.

111. Don't allow your men to wear red garments when on duty.

112. Don't hang your clothes on the roadway signs.

113. Don't use dangerously defective cars or tools.

114. Don't use bent spikes for track bolts.

115. Don't guess at the number of ties put in track each month. Count them.

116. Don't guess at the rail on your section. Measure it.

117. Don't be disrespectful to owners of land adjoining the right of way. Remember they are your neighbors.

118. Don't permit material or buildings to be placed too near the track.

119. Don't put wedges and shims between principal members of trusses.

120. Don't try to support a plate girder at an unbraced flange.

121. Don't let the nuts work off hook bolts of stringers and off guard rails.

122. Don't force rivet holes where they should be reamed.

123. Don't join members of iron bridges without first painting them.

124. Don't allow drift to accumulate at the ends of piers.

125. Don't allow tin roofs to be destroyed for the want of a little paint.

126. Don't take out too many ties and allow the track to kink in hot weather.

127. Don't fill in with ballast when the ties rest on dirt.

128. Don't make ballast margin when you have not enough material to fill in between the ties and thoroughly tamp them.

129. Don't nick, slot or dent steel rails.

130. Don't place rails in curves sharper than two degrees without first curving them with a rail bender.

131. Don't allow the gage of track at frog points to vary from the standard without correspondingly adjusting the flangeway of the guard rail.

132. Don't allow your right of way fences to become dilapidated and allow stock to enter upon the right of way.

133. Don't fail to fill out all your reports carefully and intelligently; these reports are required for a purpose.

134. Don't guess at data for your broken rail reports. Read what is marked on the rail.

135. Don't allow farm gates in the right of way fence to stand open.

136. Don't secure hand or push cars behind a moving train to save the labor of pumping or pushing them. Many serious accidents have happened from this cause. If a train should slacken speed, or suddenly stop, with a hand car attached, it would be hard to prevent the car from going under the coach or

caboose, and the men on the car might be injured or killed.

137. Whenever you receive a message from your roadmaster which requires an answer, don't wait or delay, but answer it promptly and correctly.

138. **Miscellaneous hints.** The man who takes advantage of published data becomes 100 years old in experience before he is 30 years old in life; therefore, cultivate the habit of learning new methods from books and periodicals, and then don't wait to see them used but apply them yourself, even if you have to devise some details that are not described.

139. Get a loose leaf notebook, such as those furnished by Lefax, Philadelphia, and gradually build up for yourself your own handbook of tables and special information.

140. Responsibility without authority and authority without responsibility are fatal to successful work.

141. The adoption of a new idea does not indicate that you have not had proper experience. Opposition to a new idea simply means that you are too "hidebound" to appreciate its value.

142. Each foreman should keep a small diary in which to jot down the principal events of the day. This may turn out to be very useful to him and to his employers, especially in the event of lawsuits.

143. One of the secrets of successful management consists in quickly finding out who are the inefficient men of the gang. The best foremen always hail from Missouri. Remember that in order to get the most successful work out of a man for his money he must have a stronger incentive to do his best than the mere fear of discharge for incompetency.

144. The safe-guarding of the lives of your men or their hands and feet is worth money to your employer as well as to the men themselves.

145. Don't use a high priced man to do a low priced

man's work and don't try to use a low priced man to do a high priced man's work. He won't do it anyway.

146. Get the habit of instinctively thinking of your work in terms of dollars; your employer will soon begin to think of you in the same terms.

147. Lookout for the chronic "can't be done" man.

148. Do not allow timber to lie in the sun unprotected. This causes checking.

149. When piling lumber leave wide spaces between the boards and planks so that they may dry more quickly, and give the top layer considerable pitch to drain off surface water. Turn the top layer over often to prevent curling.

150. Measure or weigh all materials upon delivery.

151. In shoveling stiff clay which sticks to the shovel, dip the shovel in water between shovelfuls.

152. In shoveling sticky mud, drill holes through the bowl of the shovel so that suction will not cause the mud to stick.

153. In excavating a bank of earth lay down a temporary floor so that earth pitched down will fall on the floor, from which it can be easily shoveled.

154. A very useful arrangement for moving heavy stones for short distances is a "skid road" such as is used by loggers. The material is carried on a sled that rides on a skid. Skids are laid like the cross ties of a railroad and are kept greased.

155. In wheelbarrow work the ideal length of haul is 25 ft. but 50 ft. is not excessive. 75 ft. is too long and 100 ft. should never be attempted when horses and carts are available.

156. Use round timber for posts of temporary trestles for trench braces, etc., wherever it can be bought for less money than sawn stuff.

157. It is much more economical to lift water by means of a good pump than by bailing it with a bucket.

158. For back filling trenches and any similar work

use the largest sized shovels at hand, and in general, when there is little or no lift the shovel can be two or three times as large as when the man has to lift the material on his shovel.

159. **Handling men.** A track foreman should be respectful to his superior officers without being servile, and when talking or writing to them he should show a confidence in himself without making too much of an exhibition of self-conceit or stubbornness, either of which will only be rewarded by their ridicule or contempt. A man who is placed over other men should have a will power strong enough to control them and maintain his authority without being either abusive or profane. To bulldoze an inferior is not the way to either instruct him or gain his respect.

160. Foremen who can keep good men, and secure more men when wanted, are more valuable to a railroad company than those who frequently discharge men and who seldom have help when it is needed.

161. Try to gain the respect of your men and you will have faithful workers. To do this it is not necessary that you be too familiar with them.

162. If you have a man working for you who will not do the work as you instruct him, discharge him and get some one who will. But do not work along in a groove, and think you have learned it all, and if any of your men suggest something which you know to be an improvement do not be ashamed to adopt it.

163. Track foremen should learn the habit of studying out the best method of doing each piece of work on which they are engaged, and when practicable have the work planned out beforehand. The mind can often do more than the hands.

164. A good track foreman will have a keen interest in his work, and be ambitious to show good results as well on the last day that he works for a company as when he was first promoted from the shovel.

165. Foremen who are not prompt in executing the orders of the roadmaster, and who often do work in a way contrary to that in which they have been instructed, seldom hold a position long on any road. This kind of men, together with that class which frequent saloons and get drunk occasionally, constitute about nine-tenths of the section foremen who are discharged for cause. Roadmasters very seldom discharge a foreman for his want of knowledge about some particular piece of work, and they are always willing to give information as to the best method of doing work when asked for it. Whenever a track foreman begins to think his work is too hard and his pay is too small, or that the officers of the road are not using him right, he becomes careless and loses all interest in the work. That man should quit at once and go hunt a job in some other place, where he might be better satisfied and appreciated. Every track foreman should make a continued effort to elevate his occupation and make it respectable. Be sober, honest and industrious and you will be successful.

166. **Section record.** The attention of trackmen generally, and especially section foremen, is here again called to the importance of keeping a record of everything connected with the piece of track in their charge. Every foreman should know the length of his section, the amount of straight and curve track, the degree of every curve, the different brands of steel or iron rail, how much of each and when laid. He should also know the number of cuts on his section and the amount of snow fence, if any, on each cut; the bridge and culvert numbers and highway or railroad crossings, and the distance they are from his headquarters; and many other facts of importance which are very valuable to assist a man in organizing work and making comparisons, also that he may be in a position to answer questions of his superior officers as to location

of places and things without the necessity of making special examinations when the time cannot well be spared. The following example illustrates a simple form for condensing the information referred to, and is a handy way for foremen to write it out on the pocket memorandum:

SECTION No. 10

Length of Section	6 miles, 1,000 feet
" " north side track	1,600 "
" " house track	1,800 "
" " north side track	1,600 "
" " south track	1,000 "

Bridge No.	No. of Bents	Length of Span	Distance from Station
50	3	30 feet	2 miles
51	8	100 "	2½ "
52	Iron	120 "	3¼ "

Culvert No.	Box	Stone	Iron Pipe	Distance from Station
186	..	1	..	1½ miles
187	..	..	1	1¾ "
188	1	..	..	2½ "

Cuts, Length in Feet	Height Above Rail	Panels of Snow Fence	Distance from Station
One 352	4 feet	22	3 miles
" 488	8 "	30½	3½ "
" 1260	9 "	89	4 "

Steel Rail, Amount	When Laid	Brand	Extends from Station
4 miles, 500 ft.	1895	N. C. R. M. Co. 75 lbs.	West— From Steel to End of Section
2 miles, 500 ft.	1899	Crawshaw 85 lbs.	

DIMENSIONS OF STANDARD FROGS AND SWITCHES FOR NARROW-GAGE INDUSTRIAL AND MINE TRACKS.

Standard Frog for Motor Turnout (Right or Left).

Frog No.	Frog Angle, X		Wt. of Rail, Lb. per Yd.	Length of Frog, A		Length of Wing Rail, B	Heel Distance, C		Length of Throat, D	Length of Straight Rail, E	
	Deg.	Min.		Ft.	In.	In.	Ft.	In.	In.	Ft.	In.
3	18	55	30	4	0	16	2	8	3 15/16	2	3
4	14	15	30	4	8	20	3	0	5¾	2	9
4	14	15	40	4	8	20	3	0	6½	3	0
5	11	25	30	4	10	20	3	2	7 3/16	3	0
5	11	25	40	5	0	20	3	4	8⅛	3	0

Standard Switch *

Wt. of Rail, Lb. per Yd.	Length of Point, F		Dist. Between Bridle Rods, L		Length of Rail Planed, H		Rail Punching, J	K	Gage of Track, G	Length of Bridle Rod M		Rod Punching, N
	Ft.	In.	Ft.	In.	Ft.	In.	In.	In.	In.	Ft.	In.	In.
20	4	0	(1 rod)		1	4	4	2	36	5	8¼	25
25	4	0	(1 rod)		1	6	4	2	40	6	0¼	29
30	4	0	(1 rod)		1	9	4	2	42	6	2¼	31
30	6	0	2	3	2	6	4	2	44	6	4¼	33
30	7	6	3	0	3	0	4	2	48	6	8¼	37
40	6	0	2	3	2	9	5	2½	—	-	—	—
40	7	6	3	0	3	6	5	2½	—	-	—	—

* The throw of switch point is 3½-in. for all cases.

DIMENSIONS FOR TURNOUTS IN NARROW-GAGE TRACKS *

Gage of Track, 36 In.

Frog No.	Length of Switch Points, F	Radius of Turnout, R		Length of Lead, S		Length of Straight Rail, T		Chord of Curved Rail, U		Middle Ordinate of Curved Rail, V
	Ft.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	In.
3	4	42	7 3/16	16	3 11/16	10	9 11/16	10	10 9/16	4 3/64
4	4	81	1½	19	3	13	5	13	8	3⅜
4	6	75	8¼	22	6	14	8	14	10⅝	4 5/16
5	4	141	7¼	22	2⅞	16	4⅞	16	7 5/16	2⅞
5	6	126	7	26	0½	18	2½	18	4¾	3 15/16
5	7½	122	9⅞	28	4½	19	0½	19	2⅝	4 7/16
6	7½	184	9⅜	30	9⅝	21	5⅝	22	9	4 3/16

Gage of Track, 42 in.

Frog No.	Length of Switch Points, F	Radius of Turnout, R		Length of Lead, S		Length of Straight Rail, T		Chord of Curved Rail, U		Middle Ordinate of Curved Rail, V
	Ft.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	In.
3	4	52	1 13/16	18	9¼	12	11¼	13	3¾	4 15/16
4	4	99	2⅛	22	3	16	5	16	8¼	4⅛
4	6	92	6⅜	25	9	17	11	18	2⅛	5¼
5	4	172	0½	25	9⅛	19	11⅛	20	2	3½
5	6	153	8⅜	29	11¼	22	1¼	22	8⅞	4 13/16
5	7½	149	1⅞	32	5½	23	1½	23	4	5 7/16
6	7½	223	5¾	36	7½	27	3½	27	6	5 1/16

* The table prepared by Mr. Brown includes five widths of track gage—36-in.; 40-in.; 42-in.; 44-in,; and 48-in. We give the figures for the 36-in. and 42-in. gages only.

Table of inches in decimals of a foot.

	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″
0	0	.083	.167	.25	.333	.417	.5—	.583	.667	.75	.833	.917
1/16 ...	.005	.089	.172	.255	.339	.422	.505	.589	.672	.755	.839	.922
1/8	.010	.094	.177	.260	.344	.427	.510	.594	.677	.760	.844	.927
3/16 ...	.016	.099	.182	.266	.349	.432	.516	.599	.682	.766	.849	.932
1/4	.021	.104	.188	.271	.354	.438	.521	.604	.688	.771	.854	.938
5/16 ...	.026	.109	.193	.276	.359	.443	.526	.609	.693	.776	.859	.943
3/8	.031	.115	.198	.281	.365	.448	.531	.615	.698	.781	.865	.948
7/16 ...	.037	.120	.203	.287	.370	.453	.537	.620	.703	.787	.870	.953
1/2	.042	.125	.208	.292	.375	.458	.542	.625	.708	.792	.875	.958
9/16 ...	.047	.130	.214	.297	.380	.464	.547	.630	.714	.797	.880	.964
5/8	.052	.135	.219	.302	.385	.469	.552	.635	.719	.802	.885	.969
11/16 ...	.057	.141	.224	.307	.391	.474	.557	.641	.724	.807	.891	.974
3/4	.063	.146	.229	.313	.396	.479	.563	.646	.729	.813	.896	.979
13/16 ...	.068	.151	.234	.318	.401	.484	.568	.651	.734	.818	.901	.984
7/8	.073	.156	.240	.323	.406	.490	.573	.656	.740	.823	.906	.990
15/16 ...	.078	.162	.245	.328	.412	.495	.578	.662	.745	.828	.912	.995

Track bolts per mile of single track.

Average Number in a Keg of 200 Pounds				Kegs per Mile—Hex. Nuts Add 6% for Square Nuts			
Size of Bolt Inches	Square Nut	Hexagonal Nut	Suitable Rail Lbs per Yd.	30 Foot Rails Joint	30 Foot Rails Holes	33 Foot Rails Joint	33 Foot Rails Holes
2½ × ⅝	390	425	30	3.31	4.96	3.01	4.51
2¾ × ⅝	379	410	35	3.44	5.16	3.13	4.70
3 × ⅝	366	395	40	3.58	5.37	3.26	4.89
3 × ¾	250	270	..	5.23	7.85	4.76	7.14
3¼ × ¾	243	261	..	5.40	8.10	4.91	7.36
3½ × ¾	236	253	50	5.57	8.36	5.06	7.59
3¾ × ¾	229	244	55–60	5.77	8.65	5.25	7.87
4 × ¾	222	236	65–70	5.97	8.95	5.43	8.15
4¼ × ¾	215	228	75	6.18	9.27	5.62	8.43
3½ × ⅞	170	180	..	7.82	11.7	7.11	10.7
3¾ × ⅞	165	175	..	8.05	12.1	7.32	11.0
4 × ⅞	161	170	..	8.28	12.4	7.53	11.3
4¼ × ⅞	157	165	80	8.53	12.8	7.75	11.6
4½ × ⅞	153	160	85	8.80	13.2	8.00	12.0
4¾ × ⅞	149	156	90–100	9.02	13.5	8.20	12.3

To find gross tons of rail per mile of track, multiply weight of rail in pounds per yard by 11 and divide by 7.

To find feet of rail per gross ton, divide 6,720 by weight of rail per yard.

To find the weight of castings by the weight of their patterns.

Multiply the weight of the white pine pattern by

16	for	cast iron.
17.1	"	wrought iron,
17.3	"	steel,
18	"	copper
25	"	lead,
12.2	"	tin,
13	"	brass,
11.4	"	zinc.

Widening of gage on curves. Rule adopted by the A. R. E. Assn. in 1910, is as follows:

Standard gage for everything up to 8° of curvature. Above 8°, increase 1/8 in. for each two degrees or fraction thereof, up to a maximum of 4′ 9½″, corresponding to a 23° curve.

Where frogs cannot be avoided on the inside of the curve, no widening of gage should be attempted, but the above rule must be modified to allow standard gage opposite the frog, or else the flangeway of the frog should be widened to compensate for the increased gage.

Lumber table—Showing number of feet, board measure, contained in a piece of joist, scantling or timber of the sizes given

Size in Inches	Length in Feet of Joists, Scantling and Timber 12	14	16	18	20	22	24	26	28	30	42	44	45
2 × 4 ..	8	9	11	12	13	15	16	17	19	20	28	29	30
2 × 6 ..	12	14	16	18	20	22	24	26	28	30	42	44	45
2 × 8 ..	16	19	21	24	27	29	32	35	37	40	53	58	60
2 × 10 ..	20	23	27	30	33	37	40	43	47	50	70	74	75
2 × 12 ..	24	28	32	36	40	44	48	52	56	60	84	88	90
3 × 4 ..	12	14	16	18	20	22	24	26	28	30	42	44	45
3 × 6 ..	18	21	24	27	30	33	36	39	42	45	63	66	68
3 × 8 ..	24	28	32	36	40	44	48	52	56	60	84	88	90
3 × 10 ..	30	35	40	45	50	55	60	65	70	75	105	110	113
3 × 12 ..	36	42	48	54	60	66	72	78	84	90	126	132	135
4 × 4 ..	16	19	21	24	27	29	32	35	37	40	56	58	60
4 × 6 ..	24	28	32	36	40	44	48	52	56	60	84	88	90
4 × 8 ..	32	37	43	48	53	59	64	69	75	80	112	118	120
4 × 10 ..	40	47	53	60	67	73	80	87	93	100	140	146	150
4 × 12 ..	48	56	64	72	80	88	96	104	112	120	168	176	180
6 × 6 ..	36	42	48	54	60	66	72	78	84	90	126	132	135
6 × 8 ..	48	56	64	72	80	88	96	104	112	120	168	176	180
6 × 10 ..	60	70	80	90	100	110	120	130	140	150	210	220	225
6 × 12 ..	72	84	96	108	120	132	144	156	168	180	250	265	270
8 × 8 ..	64	75	85	96	107	117	128	139	149	160	224	234	240
8 × 10 ..	80	93	107	120	133	147	160	173	187	200	280	294	300
8 × 12 ..	96	112	128	144	160	176	192	208	224	240	336	352	360
10 × 10 ..	100	117	133	150	167	183	200	217	233	250	350	366	375
10 × 12 ..	120	140	160	180	200	220	240	260	280	300	420	440	456
12 × 12 ..	144	168	192	216	240	264	288	312	336	360	504	528	500
12 × 14 ..	168	196	224	252	280	308	336	364	392	420	588	616	630
14 × 14 ..	196	229	261	294	327	359	392	425	457	490	686	716	735

INDEX

INDEX

ENGINEERING AND TECHNICAL BOOKS

The Clark Book Co., Inc., will be pleased to send you any of the following books or sets of books for ten days' examination,

PREPAID AND WITHOUT OBLIGATION

(Reference or membership in engineering society required. or in lieu of this a check for the amount involved, which will not be deposited, or cashed unless you purchase the books. Otherwise the check will be returned to you when you return the books in undamaged condition.)

COMPLETE SETS AT REDUCED PRICES

may be had on terms of $3 down and $3 per month. In addition to the sets noted below, we will be glad to quote special discounts on any combination of three or more books desired.

COSTS AND EQUIPMENT

Gillette's—"Cost Data" (All civil engineering)	$ 5.00
Gillette's—"Handbook of Rock Excavation. Methods and Cost"	5.00
Gillette's—"Handbook of Earth Excavation. Methods and Cost." Ready in June, 1917	5.00
Dana's—"Handbook of Construction Plant"	5.00
Gillette & Dana—"Cost Keeping and Management Engineering"	3.50

STRUCTURAL ENGINEERING

Kirkham—"Structural Engineering"	5.00
Malcolm—"Graphic Statics"	3.00
Steinman—"Melan's Steel Arches and Suspension Bridges"	3.00
Tyrrell—"Mill Buildings"	4.00
Tyrrell—"Artistic Bridge Design"	3.00
Wells—"Steel Bridge Designing"	2.50

BUILDING WORK

Walker's—"Building Estimator's Reference Book"	10.00
Gilbreth—"Field System"	3.00
Gilbreth—"Bricklaying System"	3.00

CONCRETE

Cochran—"Inspection of Concrete Construction"	4.00
Dodge's—"Diagrams for the Design of Reinforced Concrete"	4.00
Gillette & Hill—"Concrete Construction, Methods and Cost"	5.00
Heidenreich's—"Engineer's Pocketbook of Reinforced Concrete"	3.00
Reid—"Concrete and Reinforced Concrete Construction"	5.00
Reuterdahl—"Theory and Design of Reinforced Concrete Arches"	2.00
Taylor's—"Practical Cement Testing"	3.00
Tyrrell—"Concrete Bridges and Culverts"	3.00

RAILWAY WORK

Lovell's—"Practical Switchwork"	1.00
Smith—"Maintenance of Way Standards"	1.50
Smith—"Standard Turnouts"	1.00
Kindelan's—"Trackman's Helper," revised by Dana and Trimble. Ready in Feb., 1917	2.00

CLARK BOOK CO., INC., 27 William Street, New York City

Chapters: Properties of Earth, Measurement and Classification, Boring and Sounding, Clearing and Grubbing, Loosening and Shoveling, Wheelbarrows, Carts, Wagons, etc., Scrapers and Graders, Cars, Steam Shovel Work, Bucket Excavation, Cableways and Conveyors, Trenching by Hand, by Machinery, Ditches and Canals, Embankments, Earth Dams and Levees, Dredging, Hydraulic Excavation, Miscellaneous.

HANDBOOK OF CONSTRUCTION PLANT

By Richard T. Dana, Consulting Engineer, Mem. Am. Soc. C. E., Mem. A. I. M. E., Mem. Am. Soc. Eng. Contr., Mem. Gillette & Dana, Appraisal Engineers

4¾ x 7, Flexible Leather, 700 pages **$5.00**

Engineering Record: "Much valuable **data are given as to the** cost of operation of certain types **of machinery—they furnish practically** the first published basis **for selecting machinery.**"

The American City: "Mr. Dana's **volume gives the information** most necessary to engineers in making **estimates of construction** costs and in executing plans."

The Excavating Engineer: "Undoubtedly **the most complete hand**book of construction plant ever published. **Every conceivable type** of machinery and equipment."

Concrete Cement Age: "The descriptions **include practically** every type of equipment, as well as cost **data.**"

"**Railway Review:** ". . . presenting **between two covers that** which the engineer often searches **through masses of trade catalogues** and stacks of card index files to find."

The National Builder: "Many machines, **appliances, methods and** contrivances the ordinary contractor **knows but little about are here** fully described and illustrated."

COST KEEPING AND MANAGEMENT ENGINEERING

By H. P. Gillette, Consulting Engineer, Mem. Am. Soc. C. E., Am. Soc. M. E., and Richard T. Dana, Consulting Engineer, Mem. Am. Soc. C. E., Am. Inst. M. E., Am. Soc. Eng. Contr., Mem. Gillette & Dana, Appraisal Engineers

Cloth, 6 x 9 inches. 350 pages **$3.50**

This work is to the construction engineer **what Taylor's "Shop** Management" and "Principles of Scientific **Management" are to** the shop foreman and superintendent.

Complete Chapter Headings

I, The Ten Laws of Management; II, **Rules for Securing Mini**mum Cost; III, Piece Rate, Bonus and Other **Systems of Payment;** IV, Measuring the Output of Workmen; V, **Cost Keeping; VI, Office** Appliances and Methods; VII, Bookkeeping **for Small Contractors;** VIII, Miscellaneous Cost Report Blanks **and Systems of Cost Keeping.**

SURVEYORS' HANDBOOK

By T. U. Taylor

Leather, 328 pages, illustrated **$2.00**

Describes the instruments, their care **and adjustment, and the** methods practiced in making surveys **of all kinds. Extensive tables** are given to facilitate calculations.

Chapter Headings

Chain Surveying; Compass Surveying; **Transit Survey; Calcula**tion of Areas; Division of Land; Leveling; **Topographic Survey; Railroad Survey;** Earthwork; City Surveying; **Plotting and Letter**ing; Government Surveying; Trigonometric **Formulas; Tables, etc.,** etc.

STRUCTURAL ENGINEERING

By J. E. Kirkham, Prof. Civil Engineering, Iowa State College, Consulting Bridge Engineer, Iowa Highway Commission. Formerly Designing Engineer with American Bridge Co.

Cloth, 6 x 9, 675 pages, 452 illustrations, 3 plates $5.00

Nothing but elementary mathematics is presupposed. As the author says in his preface, the book was designed to be understood without the aid of a library of reference works.

There are fourteen chapters as follows: I, Preliminary; II, Structural Drafting; III, Fundamental Elements; IV, Theoretical Treatment of Beams; V, Theoretical Treatment of Columns; VI, Rivets, Pins, Rollers and Shafting; VII, Maximum Reactions; VIII, Graphic Statics; IX, Influence Lines; X, Descriptions of I-Beams and Plate Girders; XI, Design of Simple Railway Bridges; XII, Design of Simple Highway Bridges; XIII, Skew Bridges; XIV, Design of Buildings.

MELAN'S THEORY OF ARCHES AND SUSPENSION BRIDGES

Translated by D. B. Steinman, C. E. Ph.D., Prof. of Civil Engineering, Univ. Idaho, author of "Suspension Bridges and Cantilevers"

Cloth, 6 x 9, 310 pages, 120 illustrations $3.00

This is a complete, authorized translation of Professor Melan's masterpiece on the theory of arches.

Contents

The Flexible Arch and the Unstiffened Cable; The Stiffened Suspension Bridge; The Arched Rib (the Three Hinged Arch, Arched Rib with End Hinges, Arched Rib without Hinges, The Cantilever Arch, the Continuous Arch); Arch and Suspension Systems with Braced Web; Combined Systems; Appendix—The Elastic Theory Applied to Masonry and Concrete Arches, Temperature Variation in Steel and Masonry Bridges.

DIAGRAMS FOR THE DESIGN OF REINFORCED CONCRETE STRUCTURES

By G. F. Dodge

Cloth, 15½ x 12½, 112 pages, 43 diagrams $4.00

Founded on diagrams prepared by the author for his own use when employed as a designing engineer for a reinforcing company. No experience in mathematics required by those who do their designing from this book.

MILL BUILDINGS

DESIGN AND CONSTRUCTION

With Chapters comparing the costs of steel, wood and concrete buildings, and on exporting steel buildings

By Henry Grattan Tyrrell, C. E., author of Mill Building Construction, Concrete Bridges and Culverts, History of Bridge Engineering, Artistic Bridge Design, etc.

Cloth, 6 x 9, 490 pages, 652 illustrations, with chapter comparing wood, steel and concrete buildings $4.00

Chapter Headings

General Features and Requirements of Economic Design; Location and Site; Purpose and Arrangement; Number of Stories; Walls; Cost of Steel Buildings; Comparative Cost of Wood, Steel and Concrete Buildings; Roof Covering and Drainage; Lighting and Ventilating; Static Roof Loads; Floor Loads; Snow and Wind Loads; Crane and Miscellaneous Loads; Steel Framing; Wood Framing; Concrete

Framing; Northern Light Roof Framing; Foundations and Anchorages; Wall Details; Ground Floors; Upper Floors; Metal Arch Floors; Roofs, Non-Waterproof; Roofings, Tile, Slate, Asbestos, Slate, Wood, Composition Roofing; Corrugated Iron; Sheet Metal Roofing; Cornices, Gutters and Downspouts; Ventilators, Glass, Skylights, Windows; Monitor Windows, Doors; Factory Foot Bridges; Paint, Painting; Painting Specifications for Structural Steel Work; Engineering Department; Estimating the Quantities; Estimating the Costs; Approximate Estimating Prices; The Drafting Office; Organization of Drafting Office; Drafting Office Practice; Cost of Structural Work Shop Drawings; Directions for Exporting Steel Buildings.

ARTISTIC BRIDGE DESIGN

By Henry Grattan Tyrrel, C. E., author of Mill Building Construction, Concrete Bridges and Culverts, History of Bridge Engineering, and Mill Buildings.

Cloth, 6¼ x 9¼, 290 pages, illustrated **$3.00**

Designed to help the engineer or architect to combine beauty, utility and economy in his work.

The work is divided as follows: Principles of Design; Ordinary Steel Structures; Cantilever Bridges; Metal Arches; Suspension Bridges; Masonry Bridges; Illustrations and Descriptions.

These last are taken from representative structures all over the world, covering the general classes mentioned above and alone justify the book.

FIELD SYSTEM

By Frank B. Gilbreth

Handbook size and binding, 200 pages **$3.00**

Mr. Gilbreth made the "Cost-plus-a-fixed-sum" contract famous. This "Field System" is the book of instructions issued to all his foremen, superintendents; time and material clerks, accounting departments, etc. Valuable rules for running a job.

STEEL BRIDGE DESIGNING

By Melville B. Wells, C. E., Assoc. Prof. Bridge & Struc. Eng., Armour Inst. Technology

Cloth, 6 x 9 inches, 250 pages, 47 illustrations, 27 folding plates **$2.50**

Chapter Headings

Engineers' Work and Contracts, Bridge Manufacture; Rivets; the Design of a Roof Truss; Types and Details of Highway Bridges; Design of a Riveted Truss Highway Bridge; Types and Details of Railway Bridges; Design of a Plate Girder Railroad Bridge; Design of a Riveted Truss Railroad Bridge; A Pin Connected Bridge; Shop Drawings; Strength of Materials; Bibliography; Specifications.

CONCRETE CONSTRUCTION, METHODS AND COST

By H. P. Gillette, Consulting Engineer, and Charles S. Hill, Associate Editor of Engineering and Contracting

6½ x 9¼, cloth, 690 pages **$5.00**

Devoted to the economics of concrete for the builder of concrete structures. The authors are constantly in touch with the best and cheapest methods of concrete construction; Mr. Gillette, through his field work, and Mr. Hill, as editor of **Engineering and Contracting**.

CHAPTERS:—Methods and Cost of Selecting and Preparing Materials for Concrete; Theory and Practice of Proportioning Concrete; Making and Placing Concrete by Hand; Making and Placing Concrete by Machine; Depositing Concrete Under Water and of Subaqueous